Tauira Rangatahi Numeracy and Literacy Programme

Apps in Numeracy and Literacy Research

Nigel Calder and Anthony Campbell

June 2014

Report commissioned by

Te Wananga o Aotearoa

EXECUTIVE SUMMARY

Introduction

A key aspect of tertiary education undertaken by Te Wananga o Aotearoa (TWoA) is re-establishing engagement and success in the rangatahi space through meeting the literacy and numeracy demands for programmes at levels 1–3. TWoA has Youth Guarantee programmes that deliver introductory Sport and Leisure and Contemporary Māori Arts programmes with embedded literacy and numeracy. The purpose of this research project was to investigate tauira rangatahi attitudes towards literacy and numeracy development through the application of appropriate cultural capital in conjunction with contemporary digital technologies. The research examined the influence of iPad apps on the beliefs and attitudes of Youth Guarantee tauira towards numeracy and literacy.

Methodology

A qualitative interpretive research methodology was used for this project. This involved a case study methodology with three different Youth Guarantee classes, one each at Mangere, Tainui (Hamilton) and Rotorua. A contemporary hermeneutic lens was applied to the data that reflects the socio-cultural discourses that influence learners as they move through cycles of interpretation, action and reflection in the learning process. There were 41 tauira and eight kaiako participants altogether in the original interview groups. Tauira were all aged 18 or 19, were predominantly of Māori and Pasifika ethnicity, and came from a variety of settings. Mixed methods were used to generate the data, with the research conducted in accordance with Kaupapa Wānanga.

Conclusions

The data were consistent that the use of the iPad apps in both the numeracy and literacy areas were received very positively by tauira and were instrumental in transforming their attitudes towards both numeracy and literacy. In conjunction with responsive kaiako pedagogical approaches, the apps contributed to the development of positive attitudes towards literacy and numeracy. The reasons for this were primarily based around the fun and engagement aspects when using the maths and literacy apps, but also through the affordances of the digital pedagogical medium, such as the learning being visual, interactive and dynamic. Many found the iPad apps less threatening and easier to learn from. Tauira indicated increased enthusiasm and participation. However, several tauira commented that some of the games were too easy, or became repetitive if only engaged through the same pedagogical processes.

Within the constraint of limited access, several key cognitive aspects were identified. The data illustrated that the learning was enhanced more when the use of apps is part of the programme and the content is integrated with the other learning experiences, rather than apps being used in isolation from these aspects. The use of apps was effective in initiating learning, but also proved to be productive in the development of conceptual knowledge by enriching the students' engagement, practice of what? and the reinforcement of concepts. The use of apps permitted the differentiation of the learning experiences, with activities able to be matched to tauira or groups to suit their identified needs, and through tauira self-identification and self-selection of apps. This was particularly true for the maths apps. Overall, the data indicated that the iPad apps opened new opportunities for learning that enhanced understanding through their propensity to motivate and engage tauira, they facilitates learning in differing ways, including through the promotion of social interaction.

Tauira were observed to participate in active discussion about strategies, when they were in groups or teams. At times, they explained how to play a game or improve the playing. In other instances, they interpreted elements of a game and reported back to other tauira or the class as a whole. Each of these activities required different types of language but each included a mixture of instructional and technical vocabulary. When students were working in pairs or groups, there was often an element of peer teaching. A successful and motivational way of using the apps was when they were introduced or played as a whole class competition. Tauira collaborated on strategies within this approach and also through the simultaneous sharing of responses or screens.

Wilf Malcolm Institute of Educational Research *Te Pūtahi Rangahau Mātauranga o Wilf Malcolm*
Tauira Rangatahi Numveracy and Literacy Programme: Apps in Numeracy and Literacy Research

Page 2

There was a range of other aspects that were identified in both the tauira and kaiako interviews. These included: increased technical competency, use of Facebook pages for expository language, video recording of trips and then writing the accompanying narrative, using the iPads for numeracy in Health and Fitness programmes, and facilitating personal investigation of inquiry questions through personal online research.

Implications

The following implications were identified:

- iPad apps were best integrated in whole class, fun and inclusive ways, such as a whole class points competitions initially, but with a deliberate move towards independent activity and self-selection of apps.
- Kaiako need to request some ongoing tauira feedback and incorporate this into their review of practice and the types of apps and iPad activities utilised for particular learning.
- There needs to be ongoing kaiako professional learning, both with the learning approaches taken and the suitability and identification of apps and activities.
- As part of the differentiation of learning, there should be a progressive, orchestrated transition through to tauira self-selection of appropriate apps, to match their learning needs.
- More challenging apps that require higher-level thinking and some with contexts more suited to this age group need to be sourced and included.
- There also needs to be a range of literacy apps and usage that links to best practice in this area e.g., apps that allow for manipulating and transforming texts, eliciting responses to text, typewriting over text or images, inserting symbols or images, and organising responses graphically.
- Online comics and graphic novels could be used effectively for reading.
- Having tauira create oral and written explanations of related iPad activity such as from a tauira Facebook page, or the explanation of output from a sports analysis app, would be opportunity to enhance learning in literacy.
- iPads could be utilised for assessment, including presentations and portfolios, and to record events on video that could have an associated narrative written and produced.
- iPads could be used as digital resources instead of textbooks, also allowing an alternative independent mode for absent students to catch up on work, and for shared kaiako planning and monitoring.
- Each tauira having an iPad would enhance ownership and utility while overcoming some of the ongoing issues with password access that had locked tauira out at times.
- Tauira might have an allowance to purchase apps e.g., $20 a term.
- The availability of headphones was also suggested to lessen in-class distraction when students were working on the iPads independently.
- Finally, enabling the printing of photos was seen as a positive aspect for both the learning and engagement with the iPads and whanau.

All of the above would improve the utility of the iPads and learning to some extent, but they have varying pedagogical and financial implications. It would be up to programme co-ordinators and managers to ascertain which ones had benefits that were worth the investment of resources. A suggestion would be to include kaiako directly in this process and also to include an element of tauira voice.

Wilf Malcolm Institute of Educational Research *Te Pūtahi Rangahau Mātauranga o Wilf Malcolm*
Tauira Rangatahi Numveracy and Literacy Programme: Apps in Numeracy and Literacy Research
Page 3

TABLE OF CONTENTS

Wilf Malcolm Institute of Educational Research *Te Pūtahi Rangahau Mātauranga o Wilf Malcolm*
Tauira Rangatahi Numveracy and Literacy Programme: Apps in Numeracy and Literacy Research

Page 4

TABLE OF TABLES

TABLES OF GRAPHS

Wilf Malcolm Institute of Educational Research   *Te Pūtahi Rangahau Mātauranga o Wilf Malcolm*
Tauira Rangatahi Numveracy and Literacy Programme: Apps in Numeracy and Literacy Research

Page 5

INTRODUCTION

Te Wānanga o Aotearoa (TWoA) has a long history of innovation in education to meet the diverse needs of the various demographics in the communities that it serves. From an initial objective of addressing the needs of youth with very low educational achievement or employment skills, to providing a complete range of education qualifications up to Masters' level, TWoA has developed creative education solutions at various locations across the country to support the goals of whānau, hapu, iwi, communities, and the government. A key aspect of this commitment to education, is re-establishing work in the rangatahi space and meeting the literacy and numeracy demands for programmes at levels 1–3 in tertiary education.

The purpose of the overall project that this research project is aligned to was to support tauira rangatahi progression in literacy and numeracy development through the application of appropriate cultural capital in conjunction with contemporary digital technologies. It was anticipated that this would engage youth. The overall project sought to inform practice for teaching and learning through technology (Ako Wānanga), to be culturally relevant to rangatahi (Mātātahi Mataora), and to be cost effective, with minimal on-going cost to the organisation.

Twenty first century rangatahi in Aotearoa New Zealand are global citizens at a unique time in history. Global factors influence the local context through social, cultural and economic realities that then impact on how rangatahi in Aotearoa-New Zealand contribute to their Whānau, Iwi, Community and Aotearoa New Zealand as a whole. Youth wellness and achievement continues to be a focus for this Government with the implementation of cross department youth development strategies. These include: Supporting education and employment aspirations for youth under the *Better Public Service Targets*; the Ministry of Social Development's Youth Sector Trials; the Ministry of Education's Youth Guarantee scheme; and the Tertiary Education Commission's (TEC) Education Strategy which includes 'fees free' study and improving transitions between education and employment aimed at supporting success for youth aged 15–24.

The TEC has defined literacy as the written or oral language people use in their everyday lives and work; it includes reading, writing, speaking and listening (REF). The TEC considers that skills in this area are essential for good communication, critical thinking, and problem solving in the workforce. This includes building the skills to communicate (particularly in the workplace) for speakers of other languages. Numeracy is the bridge between mathematics and real life. It includes the knowledge and skills needed to apply mathematics to everyday family and financial matters, work and community tasks. The TEC uses the term 'literacy and numeracy' to refer to all of the literacy, language and numeracy skills described above. Results from the *International Adult Literacy* (OECD, 2000) and *Adult Literacy and Life skills (Ministry of Education, 2009)* surveys both showed that almost half of all adults 16–65 years had pressing literacy and numeracy needs.

TWoA is recognised as a Wānanga characterised by teaching, learning and research underpinned by tikanga and āhuatanga Māori. Inscribed within this identity are the TWoA pillars of focus as regards to navigating the world. These pillars acknowledge not only the functional literacies advanced by the TEC, but also cultural and critical literacies as a part of multiple literacies that they seek to maintain, enhance and advance as a way of raising consciousness. TWoA acknowledges these literacies as being inextricably linked and of equally high importance. TWoA strategy has involved (k)new thinking for many for both institutions, kaiako, and tauira.

The research study approach has been to recognise that functional literacy on its own (separated from considerations of cultural and critical literacies) does not support the advancement of the Mātauranga Māori continuum to which TWoA is committed. TWoA has developed a strategy, He Whakapahuhu Kahukura (HWK), which incorporates the capability proposal for embedding literacy and numeracy within their holistic approach. The HWK strategy is to be referred to for TWoA overall literacy and numeracy strategy.

TWoA has Youth Guarantee programmes that deliver introductory Sport and Leisure and Contemporary Māori Arts programmes with embedded literacy and numeracy. These programmes are situated in Te Tai Tokerau (Whangarei), Tamaki Makaurau (Mangere), Tainui (Hamilton and Tokoroa), Waiariki (Rotorua, Tauranga and Kawerau) Whirikoka (Gisborne) and Te Tai Tonga (Porirua) campuses. This research examined the influence of iPad apps on the beliefs and attitudes of Youth Guarantee tauira towards numeracy and literacy. The following section considers the use of numeracy and literacy apps for learning.

Wilf Malcolm Institute of Educational Research   *Te Pūtahi Rangahau Mātauranga o Wilf Malcolm*
Tauira Rangatahi Numveracy and Literacy Programme: Apps in Numeracy and Literacy Research

Page 6

THE USE OF NUMERACY AND LITERACY APPS

There has been a proliferation in the availability, and usage, of both tablets and smartphones in educative settings in recent years. While some research has been undertaken, the uptake has been so rapid as to limit the ongoing related research that might inform and validate this transition. Linked to the increase in mobile technology is the growth in apps that can be utilised for learning.

Studies have shown that the use of digital technologies in mathematics education opens up new opportunities for engaging with concepts and processes. Some educators contend that they offer the opportunity to re-envisage aspects of mathematical education, along with alternative ways to facilitate understanding (e.g., Borba & Villareal, 2005; Calder, 2011). For instance, the visual and dynamic elements of engaging mathematical thinking through digital technologies repositions the types of knowledge and understanding required. This simultaneously shapes the learning experience in a range of inter-related ways. Borba and Villareal (2005) argued that information and communication technology (ICT) emphasises the visual aspect of mathematics. Likewise, the opportunities afforded to the exploration and transformation of data with digital technology reveals fresh approaches to analysing statistics (e.g., Forbes & Pfannkuch, 2009).

For over three decades, digital technologies have been part of mathematics educator's repertoire of tools, knowledge and processes used to enhance engagement and understanding in learning and teaching (Geiger, Forgasz, Tan, Calder, & Hill, 2012). While the uptake and approach has been variable, the nature of digital technologies has changed dramatically, along with their usage and availability, which has increased over that time. Interactive whiteboards, tablets such as iPads, virtual learning environments, and smartphones have all come into common use relatively recently, offering opportunities to transform the learning experience. International research echoes and at times initiates these transformations (e.g., Confrey et al., 2010; Geiger et al., 2012; Hoyles & Lagrange, 2010). Meanwhile, the availability of apps and their inclusion into classroom programmes continues relatively unrestrained, and often escapes critical examination. Apps predominantly present the mathematical ideas and processes in a game context, often with extrinsic motivators, which use points as rewards.

The affordances of digital technologies for mathematics education are well documented (Brown, 2006; Beatty & Geiger, 2010) and there has been recognition of the incremental growth of the use of digital technologies reported through transitions in curriculum documents in, for example, New Zealand (Ministry of Education, 2007). While affordances and constraints are often identifiable to particular digital technologies (Sacristan et al, 2010), there are some that are more generically embedded through a range of settings (Calder, 2011). Others have indicated that these affordances, when facilitated appropriately by the teacher, may lead to students exploring powerful ideas in mathematics, learning to pose problems, and create explanations of their own (e.g., Sandholtz, Ringstaff & Dwyer, 1997).

Learning through apps offers potential affordances for learning that are similar to those identified within other digital technologies. Apps offer the opportunity to engage dynamically, thus gaining instantaneous feedback to input; moreover, they can link various forms of information or data (e.g., numeric, symbolic and visual) and transform them simultaneously. Influences by digital pedagogical media on student motivation and the facilitation of cognitive risk taking have also been reported (e.g., Higgins & Muijs, 1999), with relational knowledge and conceptual links enhanced (Santos-Trigo & Moreno-Armella, 2006). Games have frequently and historically been part of the mathematical learning experience (Bragg, 2011). The use of digital games in mathematics learning has been reported to facilitate engagement with spatial elements and 3-dimensional visualisation (Lowrie, 2005).

Although situated within a study examining the use of the iPad in literacy learning, Hutchison, Beschorner and Schmidt-Crawford (2012) identified some advantages and considerations of using iPads that are more generic and would be applicable to learning through mobile technologies in general. They contend that iPads power on and off very quickly, so that it is easy to integrate them spontaneously, without disrupting the learning. In addition, students were able to quickly learn to navigate the iPad, and when they did encounter problems, they worked collaboratively to resolve them, leading to enhanced conversations. Also, given the specificity of available apps and the ease of access to iPads in the class situation, teachers were more likely to spontaneously integrate the iPads into their lessons, thus enabling some dynamic, responsive differentiation of the learning for individual students.

Wilf Malcolm Institute of Educational Research *Te Pūtahi Rangahau Mātauranga o Wilf Malcolm*
Tauira Rangatahi Numveracy and Literacy Programme: Apps in Numeracy and Literacy Research

Page 7

There are indications that the use of apps has a positive influence on both attitudes to mathematics learning and student motivation in a variety of settings (Attard & Curry, 2012; Morgan, 2013; Whyte, 2012). While this is a key attribute in the engagement of learners and their subsequent learning, optimizing learning is also contingent on the appropriateness and quality of the activity that the learner is being engaged with. An analysis of mathematics apps available through the apple appstore indicated that they are predominantly designed for drill-and-practice, are variable in quality, and often labeled inaccurately in terms of the cognitive elements they are claiming to address (Larkin, 2013). Other research contends that few apps exemplify current best practice in mathematics education nor do they always integrate visual and dynamic affordances to model mathematics situations that support mathematical sense-making (Pelton & Pelton, 2012).

The context, as enacted through the back-story, locates the game or activity within the students' cultural world and evoked their initial purpose for engagement (Ainley, Pratt & Hansen, 2006). The inclusion of characters transforms the dynamics of the spatial relationships and diversifies the perspectives the game-player might take (Tversky & Hard, 2009). It was found that most students took the perspective of the character for actions or movements. While educational apps are frequently games-based (Carr, 2012; Murray & Olcese, 2011) and engaging, it is also important in mathematics education apps that the learning opportunities are embedded seamlessly within the playing of the games (Masek, Murcia, & Morrison, 2012). Implicit to successfully playing digital games is the ongoing prediction, reflection and revision of strategies (van Eck, 2006).

A study by Jorgensen and Lowrie (2012) reported that the primary driver for the practice and development of skills was speed, rather than higher order thinking. In addition, there was no disincentive for making errors, so some players were content to use trial-and-error strategies only, disregarding multiple errors rather than evolving "more complex ways of working through worlds." (Jorgensen & Lowrie, 2012, p. 384). Observations of 5-year-olds using apps in their mathematics programme, likewise identified that one or two children took a random approach to solving the puzzles, and used low-level repetitive actions rather than those that involved conscious mathematical thinking. For example, the random selection of numbers until the solution is found and the next stage engaged. The related investigation found that the use of apps was highly motivational and engaged the children in learning mathematical processes (Whyte, 2012).

An element of learning through digital games, and one that is often criticised, is their tendency to promote repetitive practice of skills. However, the context and engagement elements of learning through this pedagogical medium present an alternative perspective to what is frequently considered detrimental to the facilitation of mathematical thinking. This relates to the practice principle, as discussed by Jorgenson and Lowrie (2012). They assert that in these learning environments the nature of the game context promotes lots of practice of key skills, but not to the detriment of student engagement. In other words, the practice is embedded within the virtual worlds that the learners engage with on their own terms, hence they are motivated and the learning doesn't become boring. They also argue that students are on task for significant periods of time. They try, and then modify strategies to make the most efficient progress, even if the strategies are frequently trial and error by nature (Jorgenson & Lowrie, 2012).

Using digital technologies in mathematics learning can foster risk taking and experimentation (Calder, Brown, Hanley, & Darby, 2006), thus allowing space for students to explore. This exploration requires some shaping however. It may not occur fortuitously. The visual image may provide stimulus, but it is the subsequent thinking that is the key to the learning process. Other researchers have likewise found positive motivational effects by using digital technologies in mathematics programmes (e.g., Lancaster, 2001). Mobile technologies offer the potential to transform the learning experience both inside and outside of the classroom. They enable the learning to engage with research and analysis in an ongoing interactive manner, within a variety of settings. Lewis, Zhao and Montclare (2012), in a study using mobile technologies with the teaching of high school chemistry, likewise found they encouraged group work and interaction.

Research has also reported that iPad usage in primary-school mathematics programmes has led to greater reflective practice and higher order thinking (Attard & Curry, 2012). They found that it led to enhanced engagement and increased enthusiasm, while also affording opportunities for the teacher to broaden the range of tasks they could integrate into the learning. Carr (2012) in a study with fifth grade students learning mathematics through the use of iPads and apps found that their use at times appeared

Wilf Malcolm Institute of Educational Research   *Te Pūtahi Rangahau Mātauranga o Wilf Malcolm*
Tauira Rangatahi Numveracy and Literacy Programme: Apps in Numeracy and Literacy Research
Page 8

to initiate higher order thinking and conceptual knowledge by enhancing the students' engagement, practice and reinforcement of concepts. She also reported that the students were more motivated and engaged compared to a control group not using the mobile technology in their programme. iPads also give opportunity for the teacher to differentiate the learning for individuals or groups and foster independent learning (Dobler, 2012; Hutchison, Beschorner, & Schmidt-Crawford, 2012; O'Malley et al, 2013). However, they also advocated that teacher professional development was an essential part of effective utilisation of the mobile technology. Likewise, they identified a need for teachers to be engaged with processes that enabled them to recognise apps that were appropriate for their learning intentions, and which were also conceptually and age-appropriate for their students (O'Malley et al, 2013). Consequently, they reported improved mathematics fluency, while also recognising that there were barriers to learning unless there was a high level of technical support.

There are nearly 5000 apps in *iTunes* designed for mathematics learning. Many of these are for the practice of particular skills in hierarchical, rewards-based games (Attard & Curry, 2012; Highfield & Goodwin, 2013; Larkin, 2013). Attard and Curry (2012) found that some encouraged students to be behaviourally and affectively engaged but also acknowledged that this didn't necessarily translate to mathematical cognitive understanding. While the use of apps can offer potential for the differentiation of learning there can often be a "mismatch between ability and task." (Attard & Curry, 2012, p. 80). This might be due to the volume and breadth of choice, and the frequently inaccurate description and promotion of apps. These aspects, in conjunction with time constraints on teachers, could lead to inaccurate teacher research and the mismatch of the appropriate app to the students' learning trajectories. However, it might also derive from a lack of sufficient teacher technological pedagogical content knowledge (TPACK) to match the activity appropriately to the individual situation. Kaiako need to consider which apps might actually enhance the mathematical learning of their tauira at the appropriate and optimal time, rather than just considering whether the students are engaged and working independently. TPACK, in this context, takes time and personal experience to evolve. Either way, there appears to be a need for teacher professional development (Attard, 2013) and the evaluation of apps by professional bodies (Larkin, 2013) so that teachers might undertake more effective differentiation of learning through their use.

With the appropriate structure, apps have the potential for affective and cognitive engagement, while the affordances of interactivity and instantaneous feedback they offer, foster the learner's willingness to take risks within their learning. If the students are not working completely individually, then they can also promote active discussion (Van de Walle, Karp, & Bay-Williams, 2010). Carr (2012) also contends that multiple senses are incorporated with the use of apps, and that they might reinforce learning and support a variety of objectives.

There is also evidence that supports the use of apps in learning programmes and the contention that, if used appropriately, they enhance mathematical thinking. In situations as diverse as a Hong Kong primary-school setting (Li & Pow, 2011), a New Zealand primary school (Morgan, 2013), and a Californian middle school (Houghton Mifflin Harcourt, 2012), studies reported positive affects on student achievement. While finding the results of her study inconclusive regarding a significant conceptual impact, Carr (2012) nevertheless recognised that apps could shape student academic success, and that game-based learning apps offered the potential to enable mathematical understanding and problem-solving processes. She also acknowledged that students only having access to the iPads in mathematics lessons for 40 days was a limitation, and advocated that students be allowed to have 24-hour access, seven days a week to get a more valid indication of their effectiveness.

There are some excellent apps that foster mathematical learning, and there are teachers who have the knowledge and propensity to use them very effectively, but it is dependent on both these two conditions for effective learning to occur. iPad apps offer the potential for transforming tauira beliefs and attitudes to learning. They can foster positive attitudes to numeracy and literacy learning and be highly motivational across a range of contexts and ages (Attard & Curry, 2012; Morgan, 2013; Whyte, 2012). In a six-month trial that integrated iPads into classroom practice, Larkin (2013) reported that all of the students were positive about the experience, and that the teacher indicated that this had led to improved engagement.

Much of the discourse regarding how the use of iPads and apps influences the affective elements of the learning experience, centres on the notion of student engagement; of students being actively enthralled and motivated, often by the visual and interactive characteristics of the pedagogical medium (Carr,

Wilf Malcolm Institute of Educational Research *Te Pūtahi Rangahau Mātauranga o Wilf Malcolm*
Tauira Rangatahi Numveracy and Literacy Programme: Apps in Numeracy and Literacy Research
Page 9

2012; Hill, 2011; Li & Pow, 2011; Price, 2011). An increased motivation to learn and an indication of students being more attentive in class have also been reported (Houghton Miffin Harcourt, 2012; Li & Pow, 2011). The inclusion of game-based apps in programmes has likewise enhanced engagement and is reported to have increased enthusiasm and participation (Attard, 2013; Attard & Curry, 2012). Meanwhile, others have indicated that the use of digital games led to active discussion and inter-student interaction and collaboration (Murray & Olcose, 2011; Van de Walle et al., 2010). Mathematical games were also reported to evoke student interest with tasks that were otherwise perceived to be repetitive and boring (Carr, 2012).

iPads and digital notebooks are also used for more generic processes such as internet research, preparing reports and presentations, and communication (Suhr, Hernandez, Grimes, & Warschauer, 2010). They also reported that the use of mobile devices in the classroom enhanced Year 7 and 9 students' engagement and impacted positively on the classroom environment. iPads can also support literacy programmes through the availability of digital books. While the learning experience in eBook reading and writing is different than with printed books, these new literacies nevertheless foster approaches to suit a range of learners and cater for individual learning trajectories (Coiro, Knobel, Lankshear, & Leu, 2008). They have the potential to engage struggling readers (Reinking, 2001). There are opportunities for learners to be more tactile in their interactions with text by manipulating and transforming texts to more closely match individual needs (Larson, 2010). Some apps are designed to elicit responses to text, while other elements identified as being conducive to the development of literacy through the use of apps are those that allow students to record responses verbally; to type write over text or images; to insert symbols or images; and to organise responses graphically (Hutchison, Beschorner, & Schmidt-Crawford, 2012). They also identified features that facilitate collaboration by allowing the simultaneous sharing of responses or screens, and the use of the inbuilt cameras as valuable features with potential to enhance literacy. They concluded that " … using iPads for literacy instruction not only supported student learning, but students were also highly engaged and able to demonstrate unique and creative ways of responding to text..." (Hutchison, Beschorner, & Schmidt-Crawford, 2012, p. 23).

It is apparent that conditional to the nature and quality of the app, and the matching to particular individual learning trajectories, apps can certainly influence tauira's attitude to learning and facilitate learning effectively. On the other hand, the indiscriminate use of apps without teacher research and TPACK, is most likely going to be ineffective in supporting teacher learning objectives for the students. While many educational institutes are investing in a range of newer, more mobile technologies such as iPads and iPods, teachers are often expected to integrate the technologies into teaching and learning without the support of professional development, particularly in relation to using the technology to enhance teaching, learning and student engagement (Attard & Curry, 2012). It seems a disproportionate allocation of resource, if the vast bulk is allocated to hardware, while key aspects in enhancing the students' learning are neglected. The professional growth of the teachers and the ongoing evolution of their TPACK may be given far less priority than the acquisition of hardware. This would be detrimental to the optimisation of the students' learning.

The range in the ability and confidence of teachers to support learning through this pedagogical media, along with the greater emphasis on entertainment rather than learning with some apps also constrained the learning process. Lewis, Zhao and Montclare (2012) similarly reported lost instructional and student engagement due to technical errors, while Attard and Curry (2012) acknowledged that the initial setting up of the apps, and ongoing maintenance of the iPads, was burdensome for teachers and thus presented a barrier for their usage. The research indicated considerable potential for iPad apps to positively influence the learning experience through their inclusion in numeracy and literacy teaching and learning programmes, but it also points towards some important considerations. The use of apps, across a range of contexts and age levels enhanced learning generally, but this was conditional on the apps selected, the purpose intended, and the pedagogical processes in which they were used. The vast number and continued proliferation of available apps, and the relative ease of access to them, indicated the need for ongoing critical review of their content. Do the descriptions of the apps match their actual delivery? Are they age appropriate? This takes considerable pedagogical content knowledge in mathematics education, while also including experience and discriminatory critique of the actual usability of the app.

The research is relatively cohesive in its assertions regarding the appeal of game-based apps. Students found them engaging and motivational and advocated their inclusion in programmes. Teachers likewise reported perceptions of their influence on students' learning that echoed the students. Perhaps there is an element of novelty and a potential for interest without learning, but generally if students are motivated,

Wilf Malcolm Institute of Educational Research *Te Pūtahi Rangahau Mātauranga o Wilf Malcolm*
Tauira Rangatahi Numveracy and Literacy Programme: Apps in Numeracy and Literacy Research

Page 10

more engaged, and enjoying an element of learning, they will come to understanding more readily. The challenge is to keep the apps as part of a varied programme, to ensure that they are relevant and appropriate for the students, and for the development of apps to be ongoing and responsive to critical review.

Today's learners are engaged and generally engrossed by digital media and can use them effectively to communicate, investigate and process ideas and personal questions. However, just allowing these learners access to mobile technology is not sufficient, nor educationally ethical. It has to be resourced equitably, and have both the learners and the teachers engaged in up-skilling to enable effective use. Effective utilisation also requires having both teachers and students involved in their ongoing evaluation and dynamic development. Kaiako and tauira need to be influential in the development of apps and the ways they are used in the learning process. If the interrelated pedagogical aspects and conceptual thinking are given primacy, then apps can certainly enhance the learning experience and understanding of tauira.

Wilf Malcolm Institute of Educational Research *Te Pūtahi Rangahau Mātauranga o Wilf Malcolm*
Tauira Rangatahi Numveracy and Literacy Programme: Apps in Numeracy and Literacy Research

Page 11

METHODOLOGY

A qualitative interpretive research methodology was used for this project. This involved a case study methodology with three different Youth Guarantee classes, one each at Mangere (Auckland), Tainui (Hamilton) and Rotorua. A contemporary hermeneutic lens was applied to the data that reflects the socio-cultural discourses that influence learners as they move through cycles of interpretation, action and reflection in the learning process.

Participants

There were 41 tauira and eight kaiako participants altogether in the original interview groups, 15 tauira and four kaiako at Mangere, 14 tauira and two kaiako at Tainui, and 12 tauira and two kaiako at Rotorua. The first sets of group interviews took place in April. A number of tauira had left by the time of the second interviews in September, due to shifting, finding work or other training, or not being present on the days of the interviews at their campus. They were all aged 18 or 19 and came from a variety of settings. Several had come straight from school, while others had been unemployed and not engaged with any form of learning or training for up to approximately four years. By the nature of Youth Guarantee, they had no formal literacy and numeracy qualifications and a large proportion had left school without any qualifications. There was a mixture of ethnicities, but the great majority were Māori (particularly at the Tainui and Rotorua campuses) and Pasifika (particularly in Mangere).

Methods used to generate the data included:

1. Tauira group semi-structured interviews (two groups in each class, pre-iPad intervention).
2. Tauira attitudinal surveys, (post-iPad intervention).
3. Tauira group semi-structured interviews (two groups in each class, post-iPad intervention).
4. Kaiako group semi-structured interviews.
5. Class observational data.
6. Before and after assessments using the TEC online diagnostic tool.

The research was conducted in accordance with Kaupapa Wānanga: Koha (provided valued rangahau in areas of tertiary engagement that have been highlighted by the MoE and TEC as well as being key target areas for TwoA—rangatahi, Māori, Pasifika and use of technology); Āhurutanga (ensured that the interests, safety, well being and dignity of participants was of paramount concern at all times); Kaitiakitanga (acknowledgement of the due contributions of all people and organisations associated with the research project or publications); and Mauri Ora (the potential to improve tauira rangatahi outcomes. I don't think this s is necessary, as they are just criteria of the TWoA ethics process

Mauri ora

The outcomes of this research has the potential to improve tauira rangatahi outcomes through:

- increasing youth culture competency;
- supporting the TWoA development and usage of technology;
- increasing appropriate practices within TWoA with tauira rangatahi;
- reporting on effective practice when engaging literacy and numeracy through iPads; and
- reporting on effective practice teaching pedagogy for tauira rangatahi in particular Māori and Pasifika.

Ethical approval was gained from both TWoA ethics committee, and the University of Waikato, Faculty of Education Ethics committee.

Wilf Malcolm Institute of Educational Research *Te Pūtahi Rangahau Mātauranga o Wilf Malcolm*
Tauira Rangatahi Numveracy and Literacy Programme: Apps in Numeracy and Literacy Research

Page 12

RESULTS AND DISCUSSION

While the research question examined tauira beliefs and attitudes towards learning in numeracy and literacy, the results can be organised into three inter-related areas: the affective, cognitive, and social factors. The affective factors are related specifically to beliefs and attitudes, the cognitive to thinking and understanding, and the social to how these elements are manifest through relationships and interaction. Within these, other themes are reported on. While the research focused primarily on the beliefs and attitudes of tauira, transitions in these aspects and in conceptual understanding during pre- and post-iPad data are likewise considered. The numeracy and literacy results are considered separately, with comparisons and generalisations examined in the conclusion section.

Numeracy

Affective factors

Initial attitudes to numeracy

This section focuses on tauira initial thoughts about numeracy as articulated in the pre-iPad interview data and the tauira questionnaires. Interestingly, all the students agreed that numeracy was part of everyday life. They indicated that there was a connection between being functional in a range of everyday tasks and using numeracy. Typical responses to the question "Where do you use numeracy?" were:

> Job: If you can't add or subtract, you're going to get ripped off by the shopkeepers, it's very important, you use it every day … Yeah, bills and power bills and stuff like that.

> M: Shopping, money, time, treadmill at the gym, calories, BMI, counting exercises.

> Carrie: Everywhere.

> Ollie: Grocery shopping.

> Charlie: Yeah, it pretty much revolves round everything … you've got to know maths.

In the questionnaire data, 95% agreed or strongly agreed that maths was useful, while 90% agreed that people use maths everyday.

Most of the tauira also thought that it was important for employment, that it would make them more employable and better employees. Typical responses were:

> All of one interview group: Yes, need it to find a job.

> Carrie: To get a job.

> Mike: I just like maths cos it helps me in the future, going to have to need it when I go into the work force….

> Job: Like when you go into the army you want maths and literacy.

> Ronnie: When you're building … got to have the correct measurements otherwise your foundations won't be stable.

In the questionnaire data, 70% agreed or strongly agreed that they needed maths to get a good job, while 90% agreed or strongly agreed that maths is important.

Overall, this indicated that in spite of their lack of conceptual knowledge and frequently negative attitude towards numeracy (in the questionnaire data, only 30% disagreed or strongly disagreed that they worried about maths) that they understood the value of numeracy and by inference, given the opportunity, would prefer to improve their numeracy conceptual understanding.

Several differentiated between the types of maths that they perceived as being important. For example:

Wilf Malcolm Institute of Educational Research *Te Pūtahi Rangahau Mātauranga o Wilf Malcolm*
Tauira Rangatahi Numveracy and Literacy Programme: Apps in Numeracy and Literacy Research

Page 13

Ernie: Some parts of maths, I don't see why it's important, like algebra and stuff … when do you need that? ... measurement and that, yeah you need.

Influence of school mathematics teachers

The students' perceptions of their teachers were accessed through a question asking them 'Is there a maths teacher you can remember? Tell me a bit about them'. In general, this group retained negative perceptions of their relationship with their teachers, particularly in mathematics. Some felt they were treated inequitably, for instance:

Charlie: I had this teacher, Mr Kale, I thought he was pretty racist cos I was the only Māori in my class and I would always try and ask him questions and he would get angry so that was the first and last time I ever went to maths.

Yahni: At my old school they just used to explain it thoroughly to the kids who knew what they were doing, they would say 'oh, I get that,'—if you said you didn't get it they would say you had to catch up. Mr Sewah, he was an Indian at my college. Yeah, he was alright but he just favoured the good, the brainy ones, so he would talk to the high up there kids, so we would just sit there and tag in the books … If we asked a question he would get angry … but when the brainy kids asked he would just say 'oh, you do it like this'.

Freida: Teacher was racist.

Carrie: My teacher was grumpy….

Mike: I always … I never actually had a problem with literacy and numeracy, it was just all the teachers that spoiled it for me … many students that have dropped out, it is all … 90% is because of the teachers … the way they teach … yeah, some teachers mix it up and get you confused

Nel & Jenni: The teachers didn't support the dumber students …

Several responses indicated that the student recognised that they had influenced the relationship or that they had instigated the breakdown of an effective learning relationship e.g.,

Charlie: Not really (didn't learn with her). It wasn't so much her, it was like I never listened. No, we clashed.

Several students described the teacher they remembered in a positive frame, although sometimes contrasting their other experiences e.g.,

Laddie: Most teachers were better at learning, but I had one, everything he taught us there were two or three different ways of working it out. When I moved up the years, I used to go back to him because I couldn't understand it. He was the only one who could teach me … There were a couple of us who went back to him, he would figure it out for us.

Ollie: It was alright, I had a good teacher, he explained stuff … took us out on the field …

Carrie: Primary teachers made me happy … we played games.

Other significant and interesting aspects from the questionnaire data that related to the affective aspect were: only 15% agreed or strongly agreed that they liked school; only 20% disagreed or disagreed strongly that they would avoid maths if they could; however 45% agreed or strongly agreed that maths is interesting. There are some tensions in the data regarding the affective domain, beliefs and attitudes are often episodic and hinged to significant events so it is possible that tauira were considering different classes or time frames when they expressed slightly conflicting opinions. For instance, maths may have been fun in a primary school class but they may have worried about it in secondary school class.

The following sections consider the data from after tauira used iPad apps in their programmes. The data comes from post iPad tauira interviews and kaiako interviews. It is important to note that there was variance in the nature of this engagement sometimes due to the variance in experience, expertise and enthusiasm of kaiako with learning through iPad apps. This aspect will be considered further in the

Wilf Malcolm Institute of Educational Research *Te Pūtahi Rangahau Mātauranga o Wilf Malcolm*
Tauira Rangatahi Numveracy and Literacy Programme: Apps in Numeracy and Literacy Research

Page 14

conclusions. As well, a number of tauira had left by the time of the second interviews in September, due to shifting, finding work or other training or not being present on the days of the interviews at their campus. This may have influenced the nature of the responses over the full group.

Influence of using the iPad apps

The use of iPads apps within the teaching and learning process led to some changes in tauira attitudes towards numeracy. Most tauira felt the change was positive and enjoyed learning in the visual interactive manner that the apps chosen evoked. They enjoyed the games context.

> Karl: The maths ones are cool … you get eaten by a zombie if you don't get the answer right.

> Laddie: A game for the whole class … teams, little teams and everything about them. It's better than a book.

> Jenni: We play fast facts maths. It's a game on the iPad. We try to beat our scores and our time.

> Tom: Yeah, we're all good with our time schedules and stuff on the iPads.

> Paora: It's visual. It's cool, good for each and all of us. We all had our own one to use. Gave you an easy answer but was testing your speed and understanding. Made it a game and competition.

> Justin: I prefer using the iPads.

> Tom: Recommend they have them again next year. Need more competitions with the whole class. You think you're playing a game but you're learning as you're trying to win the game. Like to have more options with the apps. Have more free time to use them for different things—for music and recording videos and photos. Fieldwork shots.

> Hine: They're fun, easy, makes it easier. Better than plain writing.

> John: You play on them. They're active.

> Whetu: … and visual. Felt like it was more easy.

However, at one campus there was a less positive response from some tauira:

> B: We never used them much. Well not while I was here anyway.

> Wally: Don't really do maths stuff on it.

> Len: Mostly in free time. We just ask for them in breaks. We sometimes have challenges.

However, in general they enjoyed the change in pedagogical medium with learning through the games context, and indicated that they found the learning fun and engaging.

> Charlie: We had fun competitions. I liked everything about them. Yeah, it's not a book. It makes it fun.

> Laddie: Cause it's a game it makes it fun.

> Ollie: Liked the maths games. We played it as a whole class. That maths thing with the facts helps me with my learning. It makes me brainy. It's interactive. Keep maths facts, fast facts.

> Justin: It's a good way to learn. I'd like to do more this way.

> Tom: Yeah, it helped to focus, and with concentration.

> John: Made me more confident.

Some students found it a bit repetitive as a learning approach.

> Nel: Sometimes it gets boring.

> Jenni: Yeah, sometimes.

Wilf Malcolm Institute of Educational Research   *Te Pūtahi Rangahau Mātauranga o Wilf Malcolm*
Tauira Rangatahi Numveracy and Literacy Programme: Apps in Numeracy and Literacy Research
Page 15

In general though, the changes in tauira attitudes and engagement were positive, especially when the apps were integrated into the learning programme in an interactive way or as a class or group game or challenge.

Kaiako perspectives

This section describes the kaiako responses in the group interviews as they considered the tauira learning through the iPad apps and how this influenced their attitudes. Overall, they were positive about the learning experience for tauira, while also seeing potential learning opportunities. The following relate to kaiako perceptions of tauira engagement and interest as well as linking to conceptual understanding in some instances. A prominent kaiako observation was that tauira were more engaged.

> Matiu: And I've actually seen some of the tauira play it without even being told now. So they are actually starting to engage in those apps rather than going on Youtube or Facebook they are actually going in to these games and actually challenging themselves.

> D: I reckon in terms of maths games on the iPad, I think, because it's like a game they can play with it, probably they don't like reading text before using the maths stuff

They indicated that tauira enjoyed using the apps as part of the learning.

> A: super interactive, like when it came to maths, the maths games, everyone was so enthusiastic about it. And then the different games that we came up with, like we had Kim come in and she ran through some of the games that she had been doing, and from those games we made up our own games as well, and really good if you want to get team interaction games … getting them into groups and working as a team. Everyone's just thoroughly enthusiastic.

> A: More positive direction now. That all works, works hand in hand, you know.

They also indicated that these aspects led to greater tauira confidence.

> A: The value in them too, you know they value themselves more when they are confident … these have actually helped….

> Matiu: But it's challenging too, it's making them think 'wow can I do this' I'm going to put my mind to it and they focus and in between doing their mahi they're grabbing the iPad and they're figuring out things and stuff like that which is quite cool….

> M: A lot of them are actually, if they are having to do the writing side of things they'll go on to Youtube and find some music that they like and they actually plug in their headphones and they actually are working independently but still listening and doing the work but they've got their music where they're not annoying anybody else and stuff like that … so they are still doing their work … so it can be quite calming for them as well … if they do actually have to do the writing side of things.

One of the kaiako felt this growing confidence and ability to connect with the learning, allied with an emerging sense of independence was empowering for tauira and resonated with the programmes overall aims.

> A: Cos the more we allow them to take ownership of their living and their livelihood and their futures the more they will be able to see past their current situation … and where they are living and maybe see outside of there….

At times, the apps were challenging or didn't 'hook them in' to the learning. This was influenced by their personal influences as well as the nature of particular apps.

> C: I think some of them found it challenging, so it depends on what their experiences have come from high school

> C: Just depends on the day, some days they wouldn't want it and other days they are keen to participate.

Wilf Malcolm Institute of Educational Research *Te Pūtahi Rangahau Mātauranga o Wilf Malcolm*
Tauira Rangatahi Numveracy and Literacy Programme: Apps in Numeracy and Literacy Research
Page 16

A: I found if we went through an app and they didn't enjoy it, that kind of put them off the iPad in general so I kind of thought maybe I shouldn't have even used that app … but you don't know whether they are going to like that one or not.

C: It was just their first perception, when they opened it they were 'oh man I'm not six years old'… but then once they gave it a chance and they played around they were 'oh, it's actually built on, it's an app that's built on pressure, like how quickly you can enter the equations and the solutions and stuff like that….

Cognitive factors

Tauira perceptions

This leads into the theme of their conceptual understanding in numeracy. The vast majority of those students found the maths at school too difficult, leading to a sense of failure and disengagement with the subject. While this would be expected to some extent given the nature of the Youth Guarantee programme, their responses also gather insights into the reasons for that lack of conceptual understanding.

Yahni: Hard, don't really like maths. I didn't like those X + Y things.

Charlie: At school it was just hard and fast—they didn't explain things, that's why I hated it at school.

Yahni: I sat a test and I remember just writing question marks straight up. I went in for a test and had to sit there for 45 minutes and I finished in five minutes because I just 'aye, what does that mean?'

Carrie: I didn't really go to maths classes … wagged.

Freida: didn't really attend my class on maths.

Fractional numbers was a particular area identified as being problematic conceptually while there was a mixed responses to division.

Charlie: Still didn't know what it meant (fractions).

Carrie: I don't like times tables.

Kenny: I like division.

Mike: I like everything about numeracy and literacy … don't like division.

Meanwhile others indicated that it was the lack of time they were allowed that inhibited their understanding e.g.

Job: Mr Peters, he put equations up on the board and gave the brainy ones time to do it, so when like the people that didn't excel at it they were still stuck behind and he would rub it off the board quickly as and just get angry at us because we haven't finished it, he just didn't give us enough time. There are people that are brainy and people who just need a bit more time. So we found it hard to learn maths when people were rubbing things off the board. It was too fast, like with three minutes between each equation on the board, some people need way longer than that.

Mike: at my school all they did was rush us through our work and then send us for a test and none of us knew anything.

In the questionnaire data, only 10% disagreed that maths was a difficult subject for them, while 20% disagreed that maths was mainly about numbers. This may have implications for the ways they perceive and interpret numeracy especially the measurement and geometry aspects. However, an understanding of number, particularly the number system and place value are central to both those strands of numeracy while multiplicative thinking is also a key process. Interestingly, only 15% thought that maths is something that only smart people do. This resonates with their belief that maths is present in most aspects of everyday life, hence something that everyone engages with to some extent.

Wilf Malcolm Institute of Educational Research *Te Pūtahi Rangahau Mātauranga o Wilf Malcolm*
Tauira Rangatahi Numveracy and Literacy Programme: Apps in Numeracy and Literacy Research
Page 17

Kaiako perceptions

In the kaiako group interviews, the discussion about cognitive factors was often linked to tauira enhanced engagement and providing a challenge to the learning in a non-threatening way. Often, this was in the form of class or group games and competitions.

> Ash: Very positive, cos the games are really there actually. So we have the apps there that we can utilise. It's good because it's more interactive so we are able to utilise it as tutors to challenge them off against each other. See who knows what. And so in our area it seems to be pretty good and because it is more 'hands on', more practical so they are able to see the words, see the calculations and add it up on the spot as opposed to writing.

> Matiu: I guess the same as being able to actually just interact with the tauira because we are able to; they are able to engage with it a lot more so even when you are introducing the apps to them, especially the maths.

Kaiako also reported that after the initial high levels of enthusiasm and engagement, which was at times focussed on more social rather than cognitive aspects of using the iPads, tauira began to use the apps independently with their learning. They set themselves tasks based on their particular learning needs or interests.

> Matiu: And I've actually seen some of the tauira play it without even being told now. So they are actually starting to engage in those apps rather than going on Youtube or Facebook they are actually going in to these games and actually challenging themselves.

> Ash: Yeah, it keeps them quite savvy too. They are already savvy with technology, phones, so it's not a new thing to them but it's interesting where they are able to go because we've got Wifi too. It's like Matiu was saying, they've cut down on the Youtube clips and they are starting to utilise it as a tool in that respect and with regards to their learning so it's become a really good tool for them to learn off.

> A: Another thing is to take ownership. Yeah, I think more ownership, the more things they take ownership of in the classroom … if we give them incentives of iPads and the more trustworthy they become to us but to themselves as well, they don't become a hassle, they become a machine in themselves where they just focus, focus, focus. So if listening to music is going to be part of the reason why they focus, and get the job done and get it done well, then that's the way we've got to adapt the learning to.

> M: I actually have a lot of them early in the mornings coming up and asking can they start on the iPads.

Some kaiako discussed the way they introduced the apps so as to enhance the engagement with the learning.

> C: We had them in class and just had them roll them out all at once. The first day we just did one game together then try and see who could get the best score and put in a challenge around that.

> P: The next time we gave them a game, because there were a lot of apps we gave one person a different app and got them to play with it and then they had to explain it to the rest of the group, how to play it, and what the key things of the game were, what to look out for.

> B: We got to a point where we had to … we found people were getting bored with the iPads a bit and then we had to re-introduce the iPad again but it was, if you do this amount of work with the iPad, if we jump on fast track apps, if you got five, 100% under a minute then you could have your free time … when I introduced that two weeks ago, then they were like, I actually have to use my brain now … cos I want some free time … and that really worked.

> A: An improvement, it's improved their learning … gives a basic structure for them.

There were other advantages that the iPad apps afforded and ways to engage with numeracy learning within appropriate contexts that enhanced their understanding:

Wilf Malcolm Institute of Educational Research *Te Pūtahi Rangahau Mātauranga o Wilf Malcolm*
Tauira Rangatahi Numveracy and Literacy Programme: Apps in Numeracy and Literacy Research

Page 18

F: Handy for students who missed a session.

M: Need time to learn about specific apps. Linked to training—BMI—heart rates—table of times/reps—convert pounds to kilograms.

A: The mathematics side of it is such a big help because a lot of the stuff is visual, and then they can actually see it, explain it visually, especially fractions, when it comes to pizza's, perfect. Some of them didn't even know how to do fractions until it was broken down like that.

B: I've seen some good results from students who really fight the maths but when I give him a challenge and kept on pushing him he got better and better.

It also allowed kaiako to adapt the learning to suit individual learning needs; to facilitate differentiated learning.

A: I think their attention was a lot better … what helped is when you are doing maths assessments with the whole class students are finished beforehand, so they can go with things, while you are working with the ones who really need help. It's amazing, like when they first start you can hear a pin drop in class.

A: I think you have to do both … I think you have to use the iPad but also take the class and teach them … for example, the maths we were doing, some kids basic learning, learning basic facts is good but I think sometimes you have to teach them on the whiteboard, and then get them to go away and go on the iPads.

One thought that this could be further enhanced with better access to apps that enabled diagnosing student conceptual understanding.

B: Yeah, more diagnostic apps … so you can target specifically where they are lacking.

TEC online assessment

Overall, there was considerable improvement between the initial and final online numeracy assessments although this cannot be attributed to the iPad app intervention. There was a complex array of interconnected contributing aspects that would have been influential including those outside of the learning environment. The mean of the initial online numeracy assessment steps was 3.3 and the mean of the final one was 3.8.

The tables below show the changes in steps over the two assessments.

Wilf Malcolm Institute of Educational Research *Te Pūtahi Rangahau Mātauranga o Wilf Malcolm*
Tauira Rangatahi Numveracy and Literacy Programme: Apps in Numeracy and Literacy Research

Page 19

Table 1.   Number and proportion of Tauira at each numeracy step

	Step 2:	Step 3	Step 4	Step 5	Step 6
Initial step	8	7	6	4	1
Final step	3	8	7	8	
	Step 2:	Step 3	Step 4	Step 5	Step 6
Initial step	31%	27%	23%	15%	4%
Final step	12%	31%	27%	30%	

The following graph displays the number of students at each step level in both the initial and final online assessment.

Graph 1.   Tauira step in numeracy online assessment.
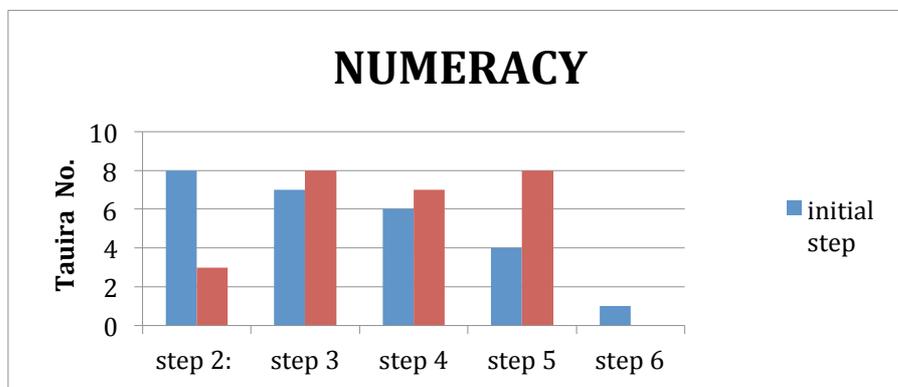
Social factors

Learning preferences

In response to the question 'Is maths fun?', games were viewed positively as a context for engaging with the mathematics. This may be due to the associated social or competitive aspects. Students generally enjoyed them and the ensuing social interaction, identifying learning through games as a positive experience e.g.,

> All: We play games, quizzes.
>
> Job: Yeah, when everyone has games about it and you stand up and have fun about it, you know, and it's fun.
>
> Yahni: They make it fun. If someone fails it's not so bad.
>
> M: Now maths is fun, our kaiako explains more. It helps learning when it's fun … games, times tables, it's a fun way to learn.
>
> Ollie: Just basically games … working with other people … rather than by ourselves….

Interestingly, in the survey data, only 60% thought that maths was boring, while 35% indicated that they thought that maths was fun. This was a lower proportion finding it boring than anticipated, but as it was not time specific it may be that there were various stages that they found it more interesting. For instance, some indicated that they were now enjoying maths due to the way it was presented in the Youth Guarantee programme, and research also indicates that there is a transition in engagement from primary to secondary school as the concepts and approaches change over that period.

Wilf Malcolm Institute of Educational Research *Te Pūtahi Rangahau Mātauranga o Wilf Malcolm*
Tauira Rangatahi Numveracy and Literacy Programme: Apps in Numeracy and Literacy Research
Page 20

Kaiako also commented on this competitive aspect in the interaction e.g.,

> A: It's like that most of the time. They don't really touch them unless we introduce them as a competition of some sort. So we've taken them through them, including spelling ones, competing with each other or on their own—which was good.

> N: A couple of them mentioned about being competitive, when it's competitive they like it, especially in the games—competitive against their score or faster or winning.

Kaiako also commented regarding their influence on other social aspects, for instance pairing up students of different ability so that there was an element of peer teaching in their interaction

> B: You could always chuck a few of the stronger ones in with the weaker ones, specifically partnering the different ones up. It helps, even with the spelling games. Fishtropolis is good because you can fluke a word but it will give the meaning of the word as well.

The approach of moving towards independence from the teacher, even when working in pairs appeared to have wider ramifications for their sense of ownership with the learning, something that kaiako felt was a key element in their overall social growth.

> A: Because the more we allow them to take ownership of their learning and their livelihood and their futures, the more they will be able to see past their current situation—and where they are living and maybe see outside of there.

Two kaiako mentioned that there were some tauira who began to get bored with using the apps in the same way over a long period and that led to them varying their approach.

> B: We got to a point where we found some people were getting bored with the iPads a bit and then we had to re-introduce the iPad again. But it was, if you do this amount of work with the iPad, if we jump on fast track apps, if you got five, 100% under a minute then you could have your free time and that really worked. We challenged them that way.

> A: I think some of them are quite needy. It's more about attention I think. So you are not actually giving them the attention that we had been giving them before say doing sports. It's like all of a sudden they've got an iPad and they have to do everything on their own. I think that is what we mean by paper based stuff is good sometimes. We were giving them the teaching.

Having the iPads available in the numeracy sessions also opened up opportunities to research situations via the internet related to problems and to collect information for their own investigations.

> A: It's awesome for instant research. If they want to know something just google it—instant answer, varied answers. Its really good. We did it with Coke and Pepsi. They just researched the companies for facts. They were very comfortable finding instant facts and researching. One of the things that we used was tanikeri. It started off really well. There were word problems in there, it wasn't really about the maths but looking at word problems or reading through maths problems. That worked out pretty good, we got most of the students going through fractions and all the percentages.

The competitive aspect and presenting taiura with a challenge was at times transformative in both their approach and their ongoing development of understanding.

> B: I've seen some good results from students who really fight the maths but when I give him a challenge and kept on pushing him he got better and better.

They liked to work on new games and share strategies about them. Kaiako at times heard them saying things like:

> A: What's the cheats, what's the cheats boys!

The data indicated that the use of iPad apps in the numeracy learning programme transformed tauira attitudes in a positive way. For some, their integration into programmes coupled with social interaction through class games and competitions, led to tauira who had been very negative towards mathematics feeling confident and willing to try new approaches. Having fun while learning maths was also a key

Wilf Malcolm Institute of Educational Research *Te Pūtahi Rangahau Mātauranga o Wilf Malcolm*
Tauira Rangatahi Numveracy and Literacy Programme: Apps in Numeracy and Literacy Research
Page 21

element in their enjoyment and enhanced engagement with numeracy. While their cognition also developed over this period, this was not necessarily related to the use of iPads hence the research was directed towards their beliefs and attitudes. This was because with reluctant learners it would be difficult to change mathematical ability significantly over a short period of time, but if attitudes towards mathematics became positive, this in time will influence conceptual understanding. In the next sections, the literacy data is reported.

Literacy

Affective factors

Initial attitudes to literacy

This section reports on tauira initial thoughts about literacy as articulated in the pre-iPad interview data and the tauira questionnaires. All the students agreed that literacy was part of everyday life with 100% indicating that most people use reading or writing everyday. 100% also recorded in the questionnaire that writing is important and that writing is useful, while 95% thought that reading helps them in their life. They indicated that there was a connection between being functional in a range of everyday tasks and using a range of literacy processes. For instance,

> W: Yes, speaking English, communicating with the people you work with. Signs—you need to be able to read signs, need to know the rules and regulations. Be able to read and check the contract, the conditions for the job.

> Ollie: Pronunciation … and communication in retailing.

> Job: If you are an instructor you need to be able to talk good.

> Kenny: You need language to communicate to people.

> Freida: To ask around and get jobs like bar tending—that's maths and language. To be an ESOL teacher.

Notably, and most probably because of their age and therefore interest in potential future employment most of these comments related to specific jobs. The data is clearly indicative of the value that they ascribe to literacy and might lead to low self-esteem if they are frustrated by their capability with written and oral communication.

Tauira engagement

The second theme identified as being influential with their beliefs and attitudes and understanding is the students' present engagement with literacy in terms of writing and reading. In answer to the interview question, 'What do you read in everyday life?' tauira answered with the following indicative responses:

> Charlie: Signs and stuff, the road code.

> W: The paper, weather update, sports articles or draws. Signs in the street and shops.

> M: Assignments—have to read stuff for them and do what you need to do.

> Job: English for doing graffiti, those big as that people do on walls. You can't sit there and not read anything, if you are on a train you are going to read where your next stop is.

> Ollie: I like reading and writing, learning new stuff when you read … pronunciation … communication.

And similarly, the responses to the interview prompt 'Tell me what writing you do':

> Tui: Texting, Facebook, sometimes when I'm bored I write lyrics … like Māori songs … songs that I already know and I just write them out … sometimes I write my own lyrics.

Wilf Malcolm Institute of Educational Research *Te Pūtahi Rangahau Mātauranga o Wilf Malcolm*
Tauira Rangatahi Numveracy and Literacy Programme: Apps in Numeracy and Literacy Research

Page 22

H: Songs, lyrics, rap music, write stuff down like your Facebook status. Write texts to friends and family.

Freida: Rap, you can make songs….

Kenny: I write on face book … texts.

Some of the comments indicated difficulty with reading and writing:

Freida: Reading is hard.

Carrie: Spelling is hard … pronunciation of some words … nothing, don't like it.

These comments were indicative of the type of comment made. Kaiako also made comments in the interviews regarding the difficulties and negative feelings some had towards writing and reading, while indicating some ways in which the iPads have fostered tauira attitudes to literacy.

M: I think a lot of them are actually quite scared of writing because their writing is so messy as well.

A: And they are ashamed of other people seeing their writing.

M: Whereas if it's being typed up they're actually a lot less stressed about what they're actually having to write.

A: It gives them self-confidence, esteem.

M: There's no stress of having to write.

N: Yeah, I think Wally said that, and he said he remembers the words now. He used to start off with little words and as well as getting longer words he is actually remembering them now. I thought he was really pleased about that, which is good.

Several spoke of using the iPads to make connections within the group such as setting up email accounts and discussing aspects of their learning. There is a lot of literacy involved with this—both directly, or the nature of the task opening up more subtle engagement e.g,, the written and oral language required to successfully set up an email account and then utilise it appropriately.

M: I've set up emails on their iPads, so their own personal email … and so with their diary writing I get them to email it to me … here's my email address, so they've got to type it in.

D: I guess in the environment where they come from too the reading is not encouraged. I think they find it challenging as well. We get them to read our mail and stuff we get them each reading a passage but probably the understanding underneath is another thing.

Kaiako also reflected on their own attitudes to having the iPads as part of the programme:

A: I love it.

M: It's been awesome—actually would be awesome if our books and stuff were on there. I think they would find that a lot more enjoyable.

A: It would be stressless.

Again as with numeracy, the data revealed a tension between tauira valuing literacy and recognising its importance to everyday life, and the difficulties many had with literacy in their previous learning experiences. This tension might well lead to a sense of frustration and negative attitudes towards literacy learning. This is an aspect to be examined further in the conclusions. This research project was concerned with the ways tauira beliefs and attitudes towards literacy may have changed through the use of iPad apps.

Cognitive factors

In this section, the data concerned with understanding and the development of literacy is considered. This concerns writing, reading, oral language and visual images.

Wilf Malcolm Institute of Educational Research *Te Pūtahi Rangahau Mātauranga o Wilf Malcolm*
Tauira Rangatahi Numveracy and Literacy Programme: Apps in Numeracy and Literacy Research

Page 23

Tauira perceptions

Tauira often referred to particular games and activities, and while often related to their enjoyment their comments frequently referred to their learning e.g.,

> Jenni: Hooked On, I like playing that because I sometimes beat people. It's easier using the iPad.

> Carlos: Hooked on Words helped your spelling and words.

> Charlie: Yeah, just fun and it makes you learn faster. Plus I've learnt new words. It makes me just want learn.

> Wally: Would have understood more if we had iPads at school. It's faster than writing it down and you learn how to do stuff through games.

Several also commented on the process used or particular affordances of the iPad that they felt enhanced the learning:

> Carrie: Learning's easier after using the iPad because it's got a variety of ways of learning. I like the visual interactive way.

> Len: I reckon its better than writing—just type it up, way better. And if you can't spell it just corrects it for you. You know how some people get so frustrated when they can't spell a word.

> Tom: I can tell heaps of my friends who don't know their vocabulary that I know heaps now. You learn at your own speed actually.

> Don: You start spell words you never knew existed. You actually learn something.

> Karl: It makes learning fun. It's more understandable—yeah.

Some commented that they didn't use the apps though but did use other things related to literacy:

> Joe: We didn't use the apps—just went on Facebook and YouTube.

> M: We used the notebook for our diary though.

> Camile: Liked using Facebook for reading and writing—just every now and then when we were allowed. Helps with words and writing.

> Norma: They explain things like clearly. It's easier for those who don't like literacy. Its good for you cos it makes you catch up on your bookwork.

> Ollie: I liked the drivers licence thing—the road code.

In one interview, all three tauira answered yes to a probing question: "Did having those sessions with the iPad help you with the literacy—your reading and talking overall?"

Kaiako perceptions

Several kaiako described the ways the iPads transformed the ways they engaged tauira with literacy especially in terms of writing, reading and research.

> A: Actually I think in both of our classes it's become our main tool of our research—video's, photos and writing. Everything, even verbal, so it's become our main tool in our classrooms.

> M: Another one for literacy is the note taking because we do a lot of diary writing, and just reflection and stuff like that.

> M: So we actually used to do it in Te Manu diaries, the student diaries that they used to get where they had to write, and it was like ugh. But the typing they like, and the keyboard skills are getting better as well.

> M: It's like note taking but Siri actually helps them with their diction because they have to pronounce the words properly, you don't slur, it has to be pronounced slowly and correctly.

Wilf Malcolm Institute of Educational Research *Te Pūtahi Rangahau Mātauranga o Wilf Malcolm*
Tauira Rangatahi Numveracy and Literacy Programme: Apps in Numeracy and Literacy Research

Page 24

D: I guess in the environment where they come from too the reading is not encouraged. I think they find it challenging as well. We get them to read our mail and stuff we get them each reading a passage but probably the understanding underneath that is another thing.

Kaiako also commented on others aspects of literacy they felt were enhanced through using the iPads, e.g., using explanations of situations or processes:

M: I also did it with Youtube. I said you find the clock that you like and then we will take a screen shot of it and then you tell me what it's about. You explain to me the different little parts of Youtube so that I can understand it a little bit better because you might know something that I'm not familiar with.

They also commented on apps that they thought had been particularly useful and engaging.

A: One that I always start the class with is Word warp.

M: Hooked on words … our guys are just jamming constantly, and they're actually starting to think about bigger words now so we are challenging them for like 'oh that's just the green tile or that's just a purple tile, or that's only three words, or a three letter word or a four letter word, I've got a blue tile, that's a seven letter word … so now they are starting to pop up with all these multi coloured tiles and they are actually taking the time to think about what words they can actually spell rather than just go for the time … so they are building their vocab.

B: We've been able to use it because we are going through the road code, some of our students are getting their licenses, we use it that way, they can go online rather than the library, and they can sit in class and do it and we can monitor them.

It appears that there are a range of opportunities to utilise the iPads to engage in literacy activities and learning beyond the use of learning apps. This will be considered further in the conclusions, particularly the implications.

TEC online assessment

There wasn't any significant improvement between the initial and final online literacy assessments, in fact, there was a slight decline. However, this cannot be attributed to the iPad app intervention. There was a complex array of interconnected contributing aspects that would have been influential including those outside of the learning environment. The mean of the initial online numeracy assessment steps was 2.6 and the mean of the final one was 2.5.

The tables below show the changes in steps over the two assessments.

Wilf Malcolm Institute of Educational Research *Te Pūtahi Rangahau Mātauranga o Wilf Malcolm*
Tauira Rangatahi Numveracy and Literacy Programme: Apps in Numeracy and Literacy Research

Page 25

Table 2.   Number and proportion of Tauira at each literacy step

	Step 1:	Step 2:	Step 3	Step 4		
Initial step	4	7	10	5		mean 2.6
Final step	1	12	12	1		mean 2.5

	Step 1:	Step 2:	Step 3	Step 4
Initial step	15%	27%	39%	19%
Final step	4%	46%	46%	4%

The following graph displays the number of students at each step level in both the initial and final online assessment.

Graph 2.   Tauira step in the online literacy assessment.
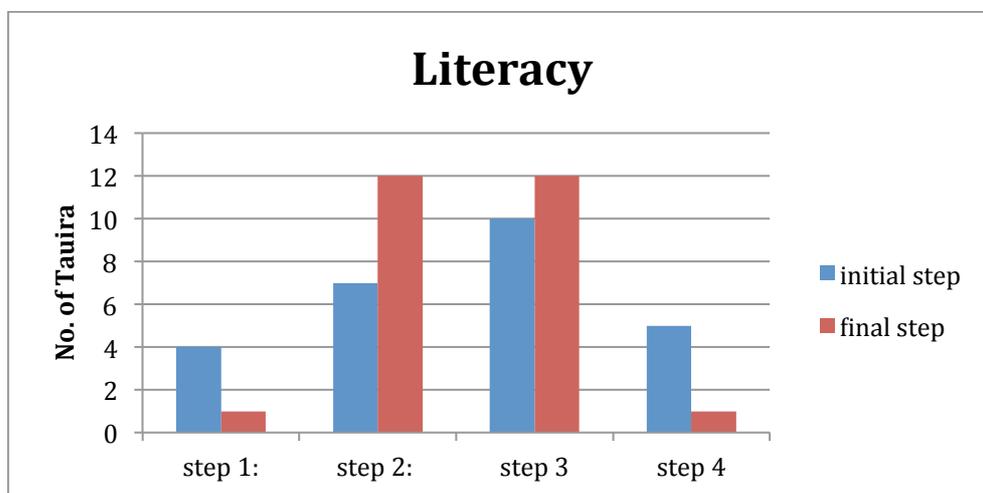
Although the small decline was surprising, there are a number of contributing factors that may have led to this. These will be discussed in the conclusions.

Social factors

Learning preferences

As mentioned, and related to the affective aspects, tauira found the games both social and fun to play, particularly when engaged in a whole class competition. While some could be played between two tauira, it was the whole class competitions that seemed to be most social and evoke the most verbal interaction e.g.,

> Tom: I like to use them competitively, playing a whole class game. Everyone gets into that one.

> Jenni: Sometimes we play with a mate and sometimes we play with the whole class. Everyone gets competitive.

> Don: Prefer class games.

> Karl: Yeah, it's funner.

> Tom: You find more places to research. Wasn't like a book where just get info from one place—there are heaps of places.

Wilf Malcolm Institute of Educational Research   *Te Pūtahi Rangahau Mātauranga o Wilf Malcolm*
Tauira Rangatahi Numveracy and Literacy Programme: Apps in Numeracy and Literacy Research
Page 26

> Charlie: If I'm sitting with someone and we have a challenge, we see who can get the most words or the highest scoring word.

However, two students didn't enjoy the iPad activities, including the social aspect.

> Mark: It's more of a distraction really.

> Ben: I don't really like them. I don't see no fun in using them.

There was less tauira comment related to social aspects of using the apps overall, but particularly in literacy. It may be that they were utilised less or in different ways. Some of the data indicate this, with one campus only having them available for three weeks.

Other aspects reported in the kaiako data

This section reports on data from the kaiako interviews that either further informed the learning approach taken or offered some alternative and potential ways to utilise the iPads. The data is sectioned into separate aspects, the first being references to approaches to teaching and learning.

Pedagogy

Kaiako indicated that they were adjusting their practice in response to the iPad availability. At times, they had reflected on, reviewed and modified their pedagogical approach.

> C: The next time we gave them a game, because there were a lot of apps, we gave one person a different app and got them to play with it and then they had to explain it to the rest of the group. How to play it, and what the key things of the game were, what to look out for.

> Ash: Yeah, it keeps them quite savvy too. They are already savvy with technology, phones, so it's not a new thing to them but it's interesting where they are able to go because we've got Wifi too. It's like Matiu was saying, they've cut down on the YouTube clips and they are starting to utilise it as a tool in that respect and with regards to their learning so it's become a really good tool for them to learn off.

> A: I think you have to do both. I think you have to use the ipad but also take the class and teach them. For example, the maths we were doing, some kids need basic learning. Learning basic facts (through apps) is good, but I think sometimes you have to teach them on the whiteboard, and then get them to go away and go on the iPads—I think that would be a whole lot easier.

> A: I think the attendance is a lot easier. What helped is when you are doing maths assessments with the whole class, students are finished beforehand so they can go and as a good pacifier I guess, while those ones, keep those ones attended to while you are working with the ones who really need help.

Administration

Kaiako made several suggestions regarding adaptions to administration that they felt would enhance the use of the iPads

> C: Assessments—we can use them and take videos of evidence or pictures of evidence to slide in with the bookwork.

> M: It's a resource that they can have and obviously they can't delete any of the bookwork, but if they had the opportunity to manage the iPad themselves with apps and stuff like that then that could be quite cool. Where they have their own apple ID's where if they wanted to buy full purchase apps then they could obviously get the itunes cards, maybe, I don't know. Or we give them a limit; say $20 per term or something like that.

> A: A combination of things, it's having the ipad in the first instance and they've taken ownership of them so you know they know it's theirs so they are actually looking after them now. We always get them back at the end of class or in some instances I've

Wilf Malcolm Institute of Educational Research *Te Pūtahi Rangahau Mātauranga o Wilf Malcolm*
Tauira Rangatahi Numveracy and Literacy Programme: Apps in Numeracy and Literacy Research

Page 27

actually signed mine out of class and we've gone on road trips with it. They have all come back.

M: I think that quite a nice little added feature would be headphones, because some of them don't have their own headphones but would like them when they're actually playing.

B: I think earphones would be good too.

A: It would be cool, going forward, also even for next year, if we have the documents there or the assignments and the students go to moodle of some sort. They can upload their own things so moving away from the paper based stuff, and when we do moderation we are not filing through a whole lot of papers just pull off those three and send them off to whoever.

M: We used to have four books, but they've actually given us like 6–7 books per kete … and it's like 'ah'.

There was some variation regarding the use of Facebook and it's value for learning. The following typifies the two sides of the discussion:

C: Is there any way we could block the Facebook? I don't know how good the literacy is in using Facebook because they talk in text language anyway, you know.

N: it can be good if they are not using any literacy at all, if they are quite negative about literacy, it can get them started in writing but it also depends if they've got to write something in more depth. That's a bit different to short snapshot sentences. They do write and read though.

C: It was just an idea. It's just distracting when they've got it minimized and they are playing one app and then when you turn and go to somebody else they go back to it and you come back and then they minimize it again.

There was also some potential to utilise them in kaiako administration:

D: Could use them for lesson sharing.

C: Teacher planning. If we had more time with them then there would have been other ways we could use them.

D: Incorporate them in all our lessons.

One suggested that whole class monitoring would enhance the learning:

D: If we had our own little screen here and we can tell this one over here is using app, so it was just set things they were all working on, this could be used for assessment too.

There were also a number of suggestions for technical aspects that kaiako felt would enhance their use and effectiveness:

B: Frank said instant research, that's probably the key. I think one issue might have been around the pass codes, we've had numerous students who have locked themselves out and we've got a couple of iPads still now that are locked and we can't open them. Connectivity issues, if one person is not connecting then it is holding back the whole class because they can't connect but that was only at the start when they were trying to connect, and still trying to upload their apps. So that was a teething thing we were going through.

A: One connectivity issue—we wanted to use some of our photo shots and tried to print them out directly from the iPad. But at the moment there's no way. I think moving forward it would be good if we would be able to print directly from the iPad.

B: Photo stream we can set up where there's accounts, across all of my devices if I take a photo with my camera.

A: Sometimes they can't get onto the internet. It's overloaded the wireless although that isn't an issue lately because they have been on it at different times, staggered.

Wilf Malcolm Institute of Educational Research   Te Pūtahi Rangahau Mātauranga o Wilf Malcolm
Tauira Rangatahi Numveracy and Literacy Programme: Apps in Numeracy and Literacy Research
Page 28

There was some innovative approaches tried at times with potential ways to further develop the overall use of the iPads.

> M: I've actually used one of the tauira's Facebook page and taken a screen shot of it and used it as the read with understanding unit. So I've taken a screen shot of it, printed it out, so he's emailed it to me, then we actually um, I've put it in front of him and said 'so what's this about?' and he's able to tell me the different features, what the conversation is about, who it is between, and actually, so it's reading and understanding so I've actually captured their evidence and put it in to his unit.

> M: We are the same, especially on the trips, we went up the mountain and these guys are taking photos of the scenery and some of them have never been up there before but they are taking those photos and then they're chucking them on Facebook and telling the world about their day.

So as soon as they are back in Wifi they are like this is what we did, this is our view, this is the mountain, this is us walking up the track. At the gym we actually downloaded a coaching app where they are able to record what they are doing and then slow it down and add little bits and pieces to make sure their technique and form is correct. But they are actually starting to critique each other and talk to each other about correcting form.

There was also comment regarding the types of apps utilised:

> C: Some were I think, and I think for the boys, a little too babyish, cartoons and funny noises and that.

> Too babyish—open them up. Little cartoons/funny music. 1 + 1 maths too easy. First perception—not 6-years old.

> A: I think we needed another session with Kim, I found we covered maybe one or two apps but because it started off so good we practiced a few apps. If we can identify the apps earlier that we want to put in front of them rather than go through an app and then that's not going to work and have to try and find something else.

The data demonstrated that kaiako were able to at times find creative solutions to overcome localised problems related to the initial implementation, but also to recognise opportunities to enhance the tauira learning within the affordances of the iPad technology. Given more opportunity to explore practice and pedagogy associated with the iPads, coupled with further facilitation with experts, their practice would continue to evolve. Just how this facilitation might manifest is considered in the conclusion. Kaiako and tauira articulated other opportunities for future ways of working:

> C: Just more specific things that include literacy and numeracy as well. Specific apps related to what we learn and do. If you are working out your BMI and heart rate and stuff like that, that's aspects of numeracy as well.

> Matiu: I think challenging them too, I've put out a couple of challenges that if you can actually clock the game by the end of the term then I'll buy the class lunch. We are still waiting for that, they've still got a couple of weeks to go but anything's possible if they really stick to it.

> C: We didn't really get to do much stuff. We've only had them for a couple of weeks and we're pretty much closing down. Thinking about next year, if we could use them for our sports folders, that would cancel out all the folders and stuff. Everyone would have all their data on their own iPad and it would just make life a whole lot easier.

> B: We've been able to use it because we are going through the road code, some of our students are getting their licenses, we use it that way, they can go online rather than the library, and they can sit in class and do it and we can monitor them … we did a challenge once and they were waiting in line to show us, to work through the road code, so that worked really well.

> D: Converting pounds to kilograms, researching themselves. Like an episode of keeping a record of their achievements, record reflections. Like a video of how they felt and what they learnt.

Wilf Malcolm Institute of Educational Research *Te Pūtahi Rangahau Mātauranga o Wilf Malcolm*
Tauira Rangatahi Numveracy and Literacy Programme: Apps in Numeracy and Literacy Research
Page 29

C: The apps were handy for students who have missed the session, so for catching up I would say: 'I'm not going to go over anatomy twice, you missed it so you watch this, and sing out if you need any help'

M: They play it back and they can actually slow it right down and can actually draw on it. Same with touch. I actually set up 2 iPads at the different ends of the court and left them running for 20 minutes recording their game. Then they could analyse the video.

N: I'm just wondering with something like that, from a language or maths point of view, you could do statistical analysis, like the number of passes, catches or tackles. You could record it and they could put the data in a table and graph them.

M: The anatomy ones and stuff like that, especially about muscles, tissue, fibres, and bones.

A: It's also a good way to research so we don't have to research for them. We can give them the tools and the questions too, especially with employment. We've had a few of our boys go on for interviews, down the road here, but for them to be able to know anything about the job they are able to do their own self- directed learning and research about the companies. So when they go for their interviews they know what the company is about.

C: Some of those apps that Kim was showing us are really helpful—Socrates or something. It has assessments already ready and they just log into the room and then they can go through and answer the questions and get instant feedback and then find their results. This is information that you can use to help plan what you are going to do with the tauira.

H. Earlier access—online assessment on iPad. Have them for all of the course.

M: I think Kim does a little bit of stuff around app development. Maybe they can develop an app that's going to help them or something. Just a thought—them working on their own app. They could develop a game, they could put it on itunes, they could patent it, and then let the world see it. All these young youths from New Zealand have actually developed these games.

M: I think that they're actually quite creative with a lot of their art stuff that they do. Even use camera filters and stuff like that. You have a look out at the front at reception and there's like four or five posters up there. Those are the ones that I took on my phone. It would be massive if we could engage with those. There's the literacy on there—they're having to come up with words and quotes and actually go and find quotes that they can put on for photos. They could do whakapapa or they could do something that inspires them, with them on it.

The last few sections point towards the generalisations that were beginning to emerge, and the contrasts and commonalities between the use of numeracy apps and the use of literacy ones. In the conclusions, these aspects will be discussed within the affective, cognitive and social aspects while again allowing space for other concepts that don't sit exclusively within those elements.

Wilf Malcolm Institute of Educational Research   *Te Pūtahi Rangahau Mātauranga o Wilf Malcolm*
Tauira Rangatahi Numveracy and Literacy Programme: Apps in Numeracy and Literacy Research
Page 30

CONCLUSIONS

Affective aspects

The data was consistent that the use of the iPad apps in both the numeracy and literacy areas were received very positively by tauira and had been instrumental in transforming their attitudes towards both numeracy and literacy. Consistent with other studies (Attard & Curry, 2012; Whyte, 2012), they contributed to the development of positive attitudes towards literacy and numeracy. The initial interviews indicated a high proportion of negative attitudes, while the questionnaire likewise contained a relatively high proportion of responses that echoed those sentiments. Despite this, the initial interviews also indicated almost total support for the notions that numeracy and literacy were critical aspects of living in society and that they were both important elements of being successful in applying for jobs. The tension in these two aspects indicated that tauira experiences in literacy and numeracy had been negative over a sustained period. Beliefs and attitudes are episodic in their development, and emerge through experiences that individual's respond to in varying ways. For these tauira, both relationships with their schoolteachers and the nature of the curriculum were influential in this disjuncture between perceiving something is important and eventually not wanting to engage with it. Comments that indicated frustration, disengagement, negativity and at times hostility were articulated. To get even a small transition in attitudes would have been significant, but there was a high proportion of attitudinal change across the pre and post data.

The reasons articulated for this change were primarily that of the repackaging of the content and processes. The iPad work was only one aspect of this, along with kaiako pedagogical approaches and transformational practice. Nevertheless, the iPad component of the programme was mentioned by most tauira and kaiako as instrumental in the transition. The reasons for this were primarily based around the fun and engagement aspects when playing the maths and literacy apps, but also through the affordances of the digital pedagogical medium. Comments such as the learning being visual, interactive and dynamic were recorded and resonate with other reports of learning experiences engaged through digital media (Carr, 2012; Pelton & Pelton, 2012). Many found the iPad apps less threatening and easier to learn from. Those apps that kaiako introduced and played as class challenges were received very positively, an aspect also considered in the Social Aspect section.

The inclusion of the game-based apps in both their literacy and numeracy programmes made the learning more engaging and in much of the data, tauira appeared to have increased enthusiasm and participation. This is consistent with Attard's (2013) study. Some tasks which had previously been considered repetitive and boring, such as learning basic numeracy facts, were engaging for tauira within an apps game context. They thought of strategies to become more accurate and faster so as to progress more quickly through the stages. This is similar to Carr's (2012) findings, but needs to be tempered by comments that playing the same game repeatedly in time caused tauira to lose some motivation to play and that several tauira commented that some of the games were too easy or too babyish. Nevertheless, the vast majority of the data clearly indicated that in terms of the affective dimension of learning, the use of iPad apps in the literacy and numeracy programmes led to more positive dispositions towards learning, increased engagement, and enjoyment of the learning experiences in these areas. In general, this is in contrast with their attitudes towards literacy and numeracy prior to being enrolled in a Youth Guarantee programme. While increased engagement and a more positive disposition towards learning generally transform and enhance cognitive understanding, this does not always manifest simultaneously and has to be considered within a tapestry of inter-related influences. The next section considers cognitive aspects.

Cognitive aspects

Cognitive aspects are those that are linked to thinking and understanding. There is a complex range of integrated elements that influence this and so it is not feasible to directly attribute change to one intervention. Similarly, although increased understanding has been identified with learning through digital pedagogical media in various studies (Calder, 2011; Li & Pow, 2011), some maintain that users need to be fully immersed in working with the technology for a long period of time before it is realistic

Wilf Malcolm Institute of Educational Research   *Te Pūtahi Rangahau Mātauranga o Wilf Malcolm*
Tauira Rangatahi Numveracy and Literacy Programme: Apps in Numeracy and Literacy Research

Page 31

for it to significantly influence cognitive development (Carr, 2012). Carr advocated that students be allowed to have 24-hour access, seven days a week to get a more valid indication of their effectiveness. This is not usually possible within the practical constraints of a research study, as was the case with this one.

Within that limitation, several key elements of the cognitive aspect were identified. The data illustrated that the learning is more enhanced when the use of the apps is part of the programme and the content is integrated with the other learning experiences, rather than presented in isolation. The use of apps was effective in initiating learning, but also proved to be productive in the development of conceptual knowledge by enriching the students' engagement, practice and reinforcement of concepts, aspects also identified in Carr's (2012) study.

The use of apps permitted the differentiation of the learning experiences, with activities able to be matched to tauira or groups to suit their identified needs, and through tauira self-identification and self-selection of apps. This was particularly true for the maths apps. Differentiation of the learning allows more targeted facilitation of individual learning trajectories and was likewise identified in other research (Dobler, 2012; Hutchison, Beschorner, & Schmidt-Crawford, 2012; O'Malley et al., 2013).

As well, interview and questionnaire data indicated that both kaiako and tauira perceived that there were cognitive gains in both numeracy and literacy. In general, they also felt that the apps made the learning easier and more accessible. This was consistent with the tauira gains made between the initial and final online numeracy assessment, but not with literacy where there wasn't any significant change reported. Notably, and having significant bearing on this finding, three tauira went from step 4 to step 3 in the literacy online assessment. This was unexpected and surprising given both tauira and kaiako perceptions of growth in that particular learning area. There may have been environmental factors that were influential when the final online assessment was given. Kaiako indicated that for those particular students there were extenuating circumstances in their personal lives at that time, which would have impacted significantly on their online assessments in a negative way. It is important to note though, that other research in the use of iPads in literacy identified that manipulating and transforming texts (Larson, 2010), eliciting responses to text, typewriting over text or images, inserting symbols or images, and organising responses graphically (Hutchison, Beschorner, & Schmidt-Crawford, 2012) all facilitate literacy development. These weren't specific characteristics of the literacy apps utilised in this study, which is something that is further considered in the implications for future use.

There were also some differences between campuses, with one campus having very limited time to incorporate the iPads into their practice. While acknowledging the potential benefits, some researchers have cautioned that opportunities to enhance learning can be restrained by teacher practice (Zevenbergen & Lerman, 2008). However, overall the data indicated that the iPad apps opened new opportunities for learning that enhanced understanding through their propensity to motivate and engage tauira, and facilitate learning in differing ways, and through the promotion of social interaction. The next section considers these Social Aspects.

Social aspects

For the purposes of this study, social aspects are considered to be the interactions between tauira, and between tauira and kaiako. These might include discussion for sense making or explanation, for justification of thinking and approach, or for reporting. Social media was utilised by tauira, Facebook in particular, but was not used as a vehicle for programme social interaction. It also includes the types of social structures that were utilised in the various engagements.

Tauira were observed to participate in active discussion about strategies, especially, but not exclusively, when they were in groups or teams. In these instances, they were trying to win a competitive whole class competition or version of the game. They also were observed, and reported discussing strategies when working individually on an app. At times, they explained how to play a game or improve the playing. In other instances, they interpreted elements of a game and reported back to other tauira or the class as a whole. These each required different types of language but included a mixture of instructional and technical vocabulary. When students were working in pairs or groups, there was often an element of peer teaching. This is consistent with other findings that if not working individually, the use of apps encouraged group work and interaction (Lewis, Zhao, & Montclare, 2012; Van de Walle, Karp, & Bay-Williams, 2010),

Wilf Malcolm Institute of Educational Research *Te Pūtahi Rangahau Mātauranga o Wilf Malcolm*
Tauira Rangatahi Numveracy and Literacy Programme: Apps in Numeracy and Literacy Research

Page 32

Tauira reported, and were observed, working independently on apps games and activities. This was an aspect that enabled individual differentiation of the learning, but also meant that tauira could continue with learning or being engaged if they finished a whole class activity before others. In some situations this was also used as a form of reward. Others have reported that they foster independent learning (O'Malley et al., 2013).

A successful and motivational way of using the apps was when they were introduced or played as a whole class competition. There was also informal social interaction associated with this as tauira verbalised their feelings and mutual encouragement. Tauira would also collaborate on strategies with this approach. Hutchison, Beschorner and Schmidt-Crawford (2012) also identified that aps facilitated collaboration between students by allowing the simultaneous sharing of responses or screens. This was also observed with tauira in this study. The apps and iPads were used in a variety of ways. In this way they enriched the diversity of learning approaches that were possible and facilitated both focused and incidental social interaction.

Other aspects

There was a range of other aspects that were identified in both the tauira and kaiako interviews. Some related to pedagogy. They included: increased technical competency, use of Facebook pages for expository language, video recording of trips and then writing the accompanying narrative, using the iPads for numeracy in the Health and Fitness programmes, and facilitating personal investigation or inquiry questions through personal online research.

Some of these enabled or at least suggested administration enhancements. For instance: using video evidence for assessment including portfolios and presentations, using digital resources instead of written textbooks, allowing an alternative independent mode for absent students to catch up on work, and using the iPads for shared kaiako planning and monitoring. At times, Kaiako thought it would be valuable to utilise a central control of the iPads so that all tauira could simultaneously be on the same page, enabling some focussed kaiako led instruction. As well, there were some administration suggestions that kaiako felt would improve the usability of the iPads. They suggested that each tauira having an iPad would enhance ownership and utility while overcoming some of the ongoing issues with password access that had locked tauira out at times. Another suggestion that would enhance ownership and individual responsibility was for tauira to have an allowance to purchase apps e.g., $20 a term. The availability of headphones was also suggested to lessen in-class distraction when students were working on the iPads independently. Finally, enabling the printing of photos was seen as a positive aspect for both the learning and engagement with the iPads and whānau.

All of the above would improve the utility and learning to some extent, but they have varying pedagogical and financial implications. It would be up to programme co-ordinators and managers to ascertain which ones had benefits that were worth the investment of resources. A suggestion would be to include kaiako directly in this process and also an element of tauira voice. While implications for future practice were implicit to some of the conclusions discussed, there are others that will be outlined specifically in the following section.

Wilf Malcolm Institute of Educational Research *Te Pūtahi Rangahau Mātauranga o Wilf Malcolm*
Tauira Rangatahi Numveracy and Literacy Programme: Apps in Numeracy and Literacy Research

Page 33

IMPLICATIONS

Affective aspects

It was deemed that integrating the iPad apps within the ongoing learning programme was most effective for the learning process. They were best integrated in whole class, fun and inclusive ways, such as whole class points competitions initially, but with a deliberate move towards independent activity and self-selection of the apps.

Kaiako need to request some ongoing tauira feedback and incorporate this into their review of practice and the types of apps and iPad activities utilised for particular learning.

There needs to be ongoing kaiako professional learning both with the learning approaches taken and the suitability and identification of apps and activities. The external facilitator could initiate this again in the first instance, but there is enough staff and internal resource to lead this at hui. If given an appropriate time and resource allocation, they could do an excellent job. There could also be professional learning about which apps are most suitable for the particular cognitive learning required and how to optimise that learning, that is, Technology Pedagogical and Content Knowledge (TPACK). Again we think the collective capability of the group of kaiako would allow this to be internally managed. The person could work with a facilitator but eventually take leadership of this aspect too. The other implications for cognitive aspects are discussed below.

Cognitive aspects

One key conclusion in this area was the ability of the apps and other functions of the iPad to differentiate the learning. While this differentiation might be quite teacher directed in the first instance, there should be a progressive, orchestrated transition through to tauira self-selection of appropriate apps to match their learning needs. This doesn't imply that the whole class challenges should eventually fade. On the contrary they should be maintained to allow for a range of ways of working with the apps, including individual, independent learning. When selecting apps kaiakao also need to include some more challenging apps that require higher-level thinking and some that have contexts suitable for the age group. O'Malley et al. (2013) identified this need for teachers to be able to recognise apps that were conceptually and age-appropriate for their students. It is important that there isn't a disjuncture between tauira ability and the conceptual level of the apps (Attard & Curry, 2012).

If there were kaiako or tauira with the appropriate expertise, having tauira design apps would also stimulate literacy and require in depth numeracy understanding in the area selected.

There needs to be a range of literacy apps and usage that links to best practice in this area as identified in the conclusion section. That is, apps that involve identifying and using activities that allow for the manipulating and transforming texts (Larson, 2010), eliciting responses to text, typewriting over text or images, inserting symbols or images, and organising responses graphically (Hutchison, Beschorner, & Schmidt-Crawford, 2012). Online comics and graphic novels could also be used effectively at times for reading. While some free one-off access to these was successful, having a subscription to an appropriate series could be beneficial for the literacy programme as well as being cost effective.

Using tauira for explanations about how to play the apps and how to optimise strategies would also constitute an appropriate learning experience, and not just for the learner. To explain how an app works is an appropriate means for developing oral literacy, and you also need to understand the principles and processes used in numeracy apps and hence the need for conceptual understanding in that area of numeracy. This is an implication for the social aspect too. The next section discusses further implications for the social aspect.

Wilf Malcolm Institute of Educational Research *Te Pūtahi Rangahau Mātauranga o Wilf Malcolm*
Tauira Rangatahi Numveracy and Literacy Programme: Apps in Numeracy and Literacy Research

Page 34

Social aspects

The key implications in this area unfold from the associated conclusions. Tauira need to have the opportunity to explain, share and report both orally and in writing. There needs to be continuation of a rich variety of activities, including the whole class competitions, that foster both motivation and engagement, while also having clear cognitive outcomes for tauira. These activities need to include group work and working in pairs.

Finally, an implication is using the iPads for assessment, including presentations and portfolios, and to record events on video that can have a narrative written and produced. As well, having tauira create oral and written explanations of related iPad activity such as from a tauira Facebook page or the explanation of output from a sports analysis app would be opportunity to enhance learning in literacy.

Wilf Malcolm Institute of Educational Research *Te Pūtahi Rangahau Mātauranga o Wilf Malcolm*
Tauira Rangatahi Numveracy and Literacy Programme: Apps in Numeracy and Literacy Research

Page 35

ACKNOWLEDGEMENTS

REFERENCES

Ainley, J., Pratt, D., & Hansen, A. (2006). Connecting engagement and focus in pedagogical task design. *British Educational Research Journal, 32*(1), 23–38.

Attard, C. (2013). Introducing iPads into primary mathematics pedagogies: An exploration of two teachers' experiences. In In V. Steine, L. Ball & C. Bardini (Eds.), *Mathematics education: Yesterday, today and tomorrow. Proceedings of the 36th annual conference of the Mathematics Education Research Group of Australasia* (pp. 58–65). Melbourne, VIC, Australia: MERGA.

Attard, C., & Curry, (2012). Exploring the use of iPads to engage young students with Mathematics. In J. Dindyal, L. P. Cheng & S. F. Ng (Eds.), *Mathematics education: Expanding horizons Proceedings of the 35th annual conference of the Mathematics Education Research Group of Australasia* (pp. 75–82).). Singapore: MERGA.

Beatty, R., & Geiger, V. (2010). Technology, communication and collaboration Re-thinking communities of inquiry, learning and practice. In C. Hoyles, & J-B. Lagrange (Eds.), *Mathematics education and technology—Rethinking the terrain* (pp. 250–284). New York, NY: Springer.

Borba, M. C., & Villarreal, M. E. (2005). *Humans-with-media and the reorganization of mathematical thinking: Information* and communication Technologies, modeling, experimentation and visualisation. New York, NY: Springer.

Bragg, S. (2011). "Now it's up to us to interpret it": Youth voice and visual methods in creative learning and research. In P. Thomson & J. Sefton-Green (Eds.), *Researching creative learning: Methods and issues* (pp. 88–103). New York, NY: Routledge.

Brown, J. (2006). Manifestations of affordances of a technology-rich teaching and learning environment (TRTLE). In J. Novotna, H. Moraova, M. Kratka, & N. Stehlikova (Eds.), *Mathematics in the centre. Proceedings of the 30th conference of the International Group for the Psychology of Mathematics Education* (pp. 241–-248). Prague, Czech Republic: PME.

Calder, N. S. (2011). *Processing mathematics through digital technologies: The primary years*. Rotterdam, The Netherlands: Sense.

Calder, N. S., Brown, T., Hanley, U., & Darby, S. (2006). Forming conjectures within a spreadsheet environment. *Mathematical Education Research Journal, 18(3),* 100–116.

Carr, J. (2012). Does math achievement h'APP'en when iPads and game-based learning are incorporated into fifth-grade mathematics instruction? *Journal of Information Technology Education, 11,* 269–286.

Coiro, J., Knobel, M., Lankshear, C., & Leu, D. (2008). Central issues in new literacies and new literacies research. In J. Coiro, M. Knoebel, C. Lankshear, & D. Leu (Eds.), *Handbook of research on new literacies* (pp. 1–21). New York, NY: Erlbaum.

Confrey, J., Hoyles, C., Jones, D., Kahn, K., Maloney, A., Nguyen, K., & Pratt, D. (2010). Designing software for mathematical engagement through modeling. In C. Hoyles & J.-B. Lagrange (Eds.), *Mathematics education and technology—Rethinking the terrain* (pp. 19–46). New York, NY: Springer.

Dobler (2012). *Reading Today.* Newark, Delaware: International Reading Association.

Forbes, S., & Pfannkuck, M. (2009). Developing statistical thinking: Teaching and learning. In R. Averill & R. Harvey (Eds.), *Teaching secondary school mathematics and statistics: Evidence-based practice* (pp. 93–128). Wellington, New Zealand: NZCER Press.

Wilf Malcolm Institute of Educational Research *Te Pūtahi Rangahau Mātauranga o Wilf Malcolm*
Tauira Rangatahi Numveracy and Literacy Programme: Apps in Numeracy and Literacy Research

Page 36

Geiger, V., Forgasz, H., Tan, H., Calder, N., & Hill, J. (2012). Technology in mathematics education. In B. Perry, T. Lowrie, T. Logan, A MacDonald, & J. Greenlees (Eds.), *Review in mathematics education in Australasia 2008–2011* (pp. 111–141). Rotterdam, The Netherlands: Sense.

Higgins, J., & Muijs, D. (1999). ICT and numeracy in primary schools. In I. Thompson (Ed.), *Issues in teaching numeracy in primary school* (pp. 103–116). Buckingham, England: Open University Press.

Highfield, K., & Goodwin, K. (2013). Apps for mathematics learning: A review of 'Educational' apps from the iTunes app store. In V. Steine, L. Ball & C. Bardini (Eds.), *Mathematics education: Yesterday, today and tomorrow. Proceedings of the 36th annual conference of the Mathematics Education Research Group of Australasia* (pp. 378–384). Melbourne, VIC, Australia: MERGA.

Hill, R. A. (2011). Mobile digital devices. *Teacher Librarian, 39*(1), 22–26.

Hoyles, C. (2001). Steering between skills and creativity: A role for the computer. *For the Learning of Mathematics, 21*(1), 33–39.

Houghton Mifflin Harcourt. (2012). *HMH Fuse™ algebra I: Results of a yearlong algebra pilot in Riverside, California*. Retrieved from http://www.hmheducation.com/fuse/pdf/hmh-fuse-riversidewhitepaper.Pdf

Hoyles, C., & Lagrange, J-B. (2010). In C. Hoyles, & J-B. Lagrange (Eds.), *Mathematics education and technology— Rethinking the terrain* (pp. 250–284). New York, NY: Springer.

Hutchison, A., Beschorner, B., & Schmidt-Crawford, D. (2012). Exploring the use of the iPad for literacy learning. *The Reading Teacher*, *66*(1), 15–23.

Jorgensen, R., & Lowrie, T. (2012). Digital games for learning mathematics: Possibilities and limitations. In J. Dindyal, L. P. Cheng, & S. F. Ng (Eds.), *Mathematics education: Expanding horizons*. Proceedings of the 35th annual conference of the Mathematics Education Research Group of Australasia (pp. 378–386). Singapore: MERGA.

Lancaster, L. (2001) Staring at the page: The functions of gaze in a young child's interpretation of symbolic Forms. *Journal of Early Childhood Literacy, 1*(2), 131–52.

Larkin, K. (2013). Maths education: Is there an app for that? In V. Steinle, L. Ball, & C. Bardini (Eds.), *Mathematics education: Yesterday, today and tomorrow*. *Proceedings of the 36th annual conference of the Mathematics Education Research Group of Australasia* (pp. 426–433). Melbourne, VIC, Australia: MERGA.

Larson, L. C. (2010). Digital readers: The next chapter in e-book reading and response. *The Reading Teacher, 64*(1), 15–22.

Lewis, M. S., Zhao, J., & Montclare, J. K. (2012). Development and implementation of high school chemistry modules using touch-screen technologies. *Journal of Chemical Education*, *89*(8), 1012–1018.

Li, S. C., & Pow, J. C. (2011). Affordance of deep infusion of one-to-one tablet-PCs into and beyond classroom. *International Journal of Instructional Media, 38*(4), 319–326.

Lowrie, T. (2005). Problem solving in technology rich contexts: Mathematics sense making in out-of-school environments. *Journal of Mathematical Behaviour, 24,* 275–286.

Masek, M., Murcia, K., & Morrison, J. (2012). Getting serious with iPads: The intersection of game design and teaching principals. *Australian Educational Computing, 27*(2), 34–38.

Ministry of Education. (2007). *The New Zealand curriculum.* Wellington, New Zealand: Learning Media.

Ministry of Education. (2009). *Adult literacy and life skills survey.* Wellington, New Zealand: Ministry of Education.

Morgan, J. (2013). *What is the influence of iPad apps on students' attitudes and beliefs towards multiplicative thinking.* Personal communication.

Murray, O. T., & Olcese, N. R. (2011). Teaching and learning with iPads, ready or not ? *TechTrends, 55*(6), 42–48.

OECD. (2000). *Literacy in the information age: Final report of the international adult literacy survey.* Canada: Statistics Canada

O'Malley, P., Jenkins, S., Wesley, B., Donehower, C., Rabuck, D., & Lewis, M. E. B. (2013). *Effectiveness of using iPads to build math fluency.* Paper presented at 2013 Council for Exceptional Children Annual Meeting, San Antonio, Texas.

Pelton, F. L., & Pelton, T. (2012). Sharing strategies with teachers: iPods in math class. In *Society for Information Technology & Teacher Education International Conference* (Vol. 2012, No. 1, pp. 4363–4366).

Wilf Malcolm Institute of Educational Research *Te Pūtahi Rangahau Mātauranga o Wilf Malcolm*
Tauira Rangatahi Numveracy and Literacy Programme: Apps in Numeracy and Literacy Research

Page 37

Price, A. (2011). Making a difference with smart tablets. *Teacher Librarian, 39*(1), 31–34.

Reinking, D. (2001). Multimedia and engaged reading in a digital world. In L. Verhoeven & C.E. Snow (Eds.), *Literacy and motivation: Reading engagement in individuals and* groups (pp. 195–221) Mahwah, NJ: Erlbaum.

Sacristan, A., Calder, N. S., Rojano, T., Santos, M., Friedlander, A., & Meissner, H. (2010). The influence and shaping of digital technologies on the learning- and learning trajectories-of mathematical concepts. In C. Hoyles & J-B Lagrange (Eds.), *Mathematics education and technology—Rethinking the terrain* (pp. 179–226). New York, NY: Springer.

Sandholtz, J. H., Ringstaff, C., & Dwyer, D. C. (1997). *Teaching with technology: Creating a student centred classroom*. New York, NY: Teachers' College Press.

Santos-Trigo, M., & Moreno-Armella, L. (2006). Students' Development of Mathematical Practices Based on the Use of Computational Technologies. In C. Hoyles, J-B Lagrange, L. H. Son, & N. Sinclair (Eds.), *Proceedings of 17th ICMI Study conference, Technology Revisited* (pp. 495–502). Hanoi, Vietnam: Hanoi University of Technology.

Suhr, K., Hernandez, D. A., Grimes, D., & Warschauer, M. (2010). Laptops and fourth grade literacy: Assisting the jump over the fourth grade slump. *The Journal of Technology, Learning, and Assessment, 9*(5), 1.

Tversky, B., & Hard, B. M. (2009). Embodied and disembodied cognition: Spatial perspective-taking. *Cognition*, *110*(1), 124–129.

Van de Walle, J. A., Karp, K. S., & Bay-Williams, J. M. (2010). *Elementary and middle school mathematics: Teaching developmentally* (7th ed.). Boston, MA: Allyn & Bacon.

van Eck, R. (2006). Digital game-based learning: It's not just the digital natives who are restless. *EDUCAUSE review*, *41*(2), 16.

Whyte, R.(2012). *Using iPad apps with 5-year-olds*. Personal communication.

Zevenbergen, R., & Lerman, S. (2008). Learning environments using interactive whiteboards: New learning spaces or reproduction of old technologies? *Mathematics Education Research Journal, 20*(1), 107–125.

Wilf Malcolm Institute of Educational Research *Te Pūtahi Rangahau Mātauranga o Wilf Malcolm*
Tauira Rangatahi Numveracy and Literacy Programme: Apps in Numeracy and Literacy Research

Page 38