"You play on them. They're active." Enhancing the mathematics learning of reluctant teenage students.

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This paper reports on a research project that examined the beliefs and attitudes of reluctant 16 to 18-year-old learners when using apps in their numeracy and literacy programmes. In particular, it considers the students' change of attitude towards numeracy learning. The data were consistent that the use of apps in the numeracy programme was instrumental in transforming student attitudes towards numeracy.

Introduction

The use of mobile devices such as tablets in educative settings has grown markedly in recent years. While research is emerging, the uptake has been so rapid as to limit the ongoing related research that might inform and critique this transition. Linked to the increase in mobile technology is the growth in apps that can be utilised for learning.

Some researchers contend that digital technologies offer the opportunity to re-envisage aspects of mathematical education, opening up 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 ways that content and processes are engaged. Likewise, the exploration and transformation of data with digital technology affords alternative approaches to analysing statistics (e.g., Forbes & Pfannkuch, 2009). Meanwhile, the availability of apps and their inclusion in classroom programmes continues, often without critical examination.

The affordances of digital technologies for mathematics education are well documented (Beatty & Geiger, 2010). Learning through apps offers similar potential affordances for learning (Calder, 2015). Apps offer the opportunity to engage with mathematical ideas in visual and dynamic ways, with learners receiving instantaneous feedback to input. They can link various forms of information or data (e.g., numeric, symbolic and visual) and transform them simultaneously. The use of digital games in mathematics learning has been reported to facilitate engagement with spatial elements and 3-dimensional visualisation (Lowrie, 2005).

Apps predominantly present the mathematical ideas and processes in a game context, often with extrinsic motivators, which use points as rewards. Care must be taken to ensure that the apps match the teacher's intended purpose. An analysis of mathematics apps indicated that they are variable in quality and often labelled inaccurately in terms of the cognitive aspects that they are claiming to address (Larkin, 2013). This implies a need for ongoing teacher professional learning so that they can best select apps that support and enhance the mathematical learning.

Meanwhile, research has also reported that iPad usage in primary-school mathematics' programmes has led to enhanced engagement, greater reflective practice, and higher order thinking (Attard & Curry, 2012). They found that it led to 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 with iPads and apps, found that the apps enhanced student engagement and the

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reinforcement of concepts. If the students were not working completely individually, then they also promoted active discussion (Van de Walle, Karp, & Bay-Williams, 2010).

iPad apps offer the potential for transforming student beliefs and attitudes to learning. They can foster positive attitudes to numeracy learning and be highly motivational (Attard & Curry, 2012). In a six-month trial that integrated iPads into classroom practice, Attard (2013) reported that all of the students were positive about the experience, and that the teacher indicated that this had led to improved engagement. Carr (2012) also reported that the students were more motivated and engaged compared to a control group not using the mobile technology in their programme.

Much of the discussion 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, 2012; Li & Pow, 2011). An increased motivation to learn and an indication of students being more attentive in class have also been reported (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 & Curry, 2012).

In a study with pre-service teachers, Grootenboer (2008) reported that student beliefs and attitudes are often the accumulation of significant episodic events. Positive classroom episodes that included apps might be influential in changing student beliefs and attitudes towards mathematics. Enhancement of learning was seen to be conditional on the apps selected, the purpose intended, and, in particular, the pedagogical processes in which they were used (Calder, 2015). However, at present there is a lack of research into this relationship within the context of apps and mobile devices in the mathematics classroom.

This research project was undertaken at Te Wananga o Aotearoa (TWoA) a tertiary institute conceived and developed under the cloak of New Zealand Maori kaupapa – a set of values, principles and plans that underpin its philosophy. TWoA has Youth Guarantee programmes that deliver introductory Sport and Leisure and Contemporary Māori Arts programmes with embedded literacy and numeracy. These Youth Guarantee programmes are for 16 to 18-year-olds who leave school without any formal qualifications, and frequently have negative attitudes to school. The research question was: In what ways did the use of iPad apps influence the beliefs and attitudes of Youth Guarantee students towards numeracy and literacy? However, this paper is concerned with changes in attitude towards numeracy learning.

Methodology

A qualitative interpretive research methodology was used for this project. This involved case studies with three different Youth Guarantee classes. An interpretive lens was applied to the data that reflects the sociocultural discourses that influenced learners as they moved through cycles of interpretation, action and reflection in the learning process. A Vygotskian sociocultural perspective also theoretically informed the project. The project considered that learning is mediated by language and the use of tools. Hence, not only does the dialogue of the teacher and the learners in the classroom act as a mediator, but also the app itself acts as a mediating tool. The learner's preconceptions of the pedagogical media, in conjunction with the opportunities and constraints offered by the media itself, promote distinct pathways in the learning process. That is, mathematical activity is inseparable from the pedagogical device, derived as it is from a particular understanding of social

organisation. This pedagogical device is more than an environment. It is imbued with a complexity of relationships evoked by the users and the influence of underlying discourses.

Participants

There were 41 student and eight teacher participants altogether in the original interview groups. A number of students had left by the time of the second interviews, 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 16 to 18 and came from a variety of settings. 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 and Pasifika. The teachers (kaiako) were responsible for selecting the apps, in conjunction with a contracted external facilitator.

Methods

Methods used to generate the data included: Student group semi-structured interviews (two groups in each class, pre-iPad intervention); student attitudinal surveys, (post-iPad intervention); student group semi-structured interviews (two groups in each class, post-iPad intervention); teacher group semi-structured interviews; class observational data; and before and after assessments using the Tertiary Education Commission (TEC) online diagnostic tool. The survey contained both quantitative and qualitative data with 19 questions using a 5-point point-scale and three open-ended questions. The TEC online adult assessment is designed to identify learner's strengths and weaknesses in numeracy. It draws from a database of problems set in adult contexts. Typically, students do about 30 questions, but this varies due to the adaptive online nature of the Assessment Tool. The researchers only had access to the individual students' level scores, not the component parts. Level one indicated the lowest conceptual understanding.

The research was conducted in accordance with Kaupapa Wānanga: Koha (provided valued research); Āhurutanga (ensured the wellbeing and dignity of participants); Kaitiakitanga (acknowledgement of the contributions of all people associated with the research); and Mauri Ora (the potential to improve student outcomes).

Results and Discussion

Interestingly, all the students agreed that numeracy was part of everyday life. They articulated 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:

> Jed: 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.

> 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 every day. As well, 70% agreed or strongly agreed that they needed maths to get a good job, while 90% agreed or strongly agreed that maths is important. Most of the students 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.

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

While they were consistent in the acceptance of mathematics as a valuable aspect of being an informed citizen, their self-efficacy and attitude towards mathematics was often negative. They attributed some of their negative attitude to their 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:

> Nel & Jenni: The teachers didn't support the dumber students …
>
> 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.
>
> Charlie: At school it was just hard and fast…they didn't really explain things. That's why I hated it at school.

This perception, coupled with the lingering negativity towards mathematics, gestures towards the need to reshape the mathematics learning experience for these particular students. Another interesting aspect from the questionnaire data was that 80% agreed that they would avoid maths if they could. However, 45% agreed or strongly agreed that maths is interesting.

TEC Online Assessment

The initial pre-app intervention assessment results for this group were low, with step 2 the most common level, and most students at steps 2 and 3. In the post-app intervention assessment, steps 3 and 5 were the most common levels, with most students at steps 4 and 5. Overall, there was greater than expected improvement between the initial and final online numeracy assessments although this cannot be attributed solely to the iPad app intervention. The mean of the initial online numeracy assessment steps was 3.3 and the mean of the final one was 3.8. In a hypothesis test for the difference in the two means, z = 1.65, which is significant at the 90% level. So at this level, we can conclude that there was a difference between the two means. There was a complex array of interconnected contributing aspects that would have been influential in this improvement, including those outside of the learning environment.

The following graph compares the initial and final online assessment.

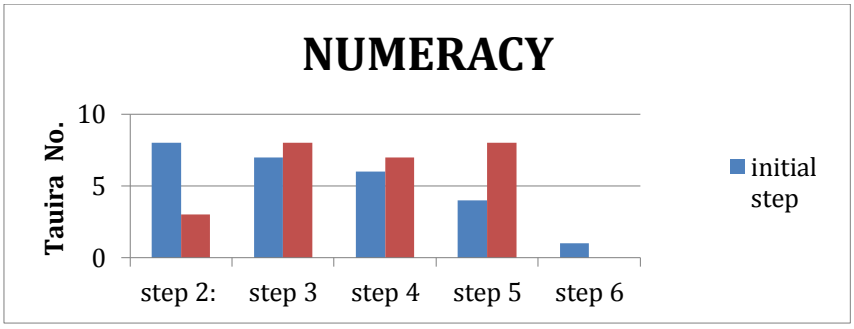

Figure 1. Student step in numeracy online assessment

Influence of using the iPad apps

The use of iPads apps within the teaching and learning process led to some changes in students' attitudes towards numeracy. Most students felt the change was positive and

enjoyed learning in the visual interactive manner that the apps evoked. They enjoyed the change in pedagogical medium and found the learning fun and engaging. Typical comments were:

> Paora: It's visual. It's cool, good for each and all of us. We all had our own one to use.
>
> 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.
>
> 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.
>
> 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.

In general though, the changes in student 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. Teachers were positive about the learning experience for students, while also seeing potential learning opportunities. A prevalent teacher observation was that students were more engaged. They indicated that students enjoyed using the apps as part of the learning.

> Anthony: 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. They are really good if you want to get team interaction games. Also, getting them into groups and working as a team. Everyone's just thoroughly enthusiastic.

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

> Ben: They (the students) value themselves more when they are confident. These have helped.

Another teacher commented on the use of apps for games and competitions.

> Ash: Very positive. It's good because it's more interactive so we are able to utilise it as tutors to challenge them off against each other. You see who knows what. It's more 'hands on', more practical so they are able to see the calculations and add it up on the spot as opposed to writing.

The apps games were viewed positively as a context for engaging with the mathematics. Students generally enjoyed them and the ensuing social interaction, identifying learning through games as a positive experience. For example,

> Manu: Now maths is fun, our teacher explains more. It helps learning when it's fun … games, times tables, it's a fun way to learn.

The data indicated that the use of iPad apps in the numeracy learning programme transformed student attitudes in a positive way. For some, their integration into programmes coupled with accompanying social interaction, led to students who had been very negative towards mathematics feeling confident and willing to try new approaches. While their cognition also developed over this period, this was not necessarily related to the use of iPad apps, hence the research was directed towards their beliefs and attitudes. 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.

Conclusions

The data were consistent that the use of the iPad apps in Youth Guarantee numeracy programmes was received very positively by students and had been influential in transforming their attitudes towards numeracy. Consistent with other studies (e.g., Attard & Curry, 2012), they contributed to the development of positive attitudes towards 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. The data indicated that student experiences in 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 students, 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 because of the repackaging of the content and processes. The iPad work was only one aspect of this, along with teacher pedagogical approaches and transformational practice. The students' learning was mediated by the use of the pedagogical device (the iPad) and the language associated with this usage. Most of the students and teachers responded that the iPad component of the programme was instrumental in the transition. The reasons for this were based around the fun and engagement aspects when engaging with the maths 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 the learning experiences of primary-aged students who engaged mathematics through an apps pedagogical medium (Carr, 2012; Pelton & Pelton, 2012). Many found the iPad apps less threatening and easier to learn from.

The inclusion of the game-based apps in their numeracy programme made the learning more engaging for the students and in much of the data, they facilitated 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 students within an apps game context. This needs to be tempered by comments that playing the same game repeatedly in time caused students to lose some motivation to play, and that several students 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 numeracy programme 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 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.

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 students verbalised their feelings and mutual encouragement. Students collaborated on strategies with this approach. Hutchison, Beschorner and Schmidt-Crawford (2012) also identified that apps facilitated collaboration between students by

allowing the simultaneous sharing of responses or screens. This was also observed with students in this study. The apps and iPads were used in a variety of ways that enriched the diversity of learning approaches that were possible, and facilitated both focused and incidental social interaction. Hence, the mathematical activity was inseparable from the pedagogical device and the social interaction that was facilitated through the use of the apps.

The research was relatively cohesive regarding the appeal of game-based apps for learners. Students found them engaging and motivational, and advocated their inclusion in programmes. As well, teachers reported perceptions of their positive influence on students' attitude to learning that echoed the students. Perhaps there is an element of novelty and a potential for being engaged without learning, but generally if students are motivated, more engaged, and enjoying an element of learning, they will come to understanding more readily. Central to them enhancing the learning in an engaging manner, is keeping 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. Case studies give insights into particular situations but are limited in terms of generalising behaviour or learning. Nevertheless, they do enhance an accumulating body of research. Another limitation of the research was that the researchers interpreted the data through their prevailing discourses and preconceptions. While awareness of this meant that consideration was given to alternative perspectives, with an interpretive approach, the researchers were unlikely to completely escape the influence of personal perspectives.

Today's learners can use digital media effectively to communicate, investigate and process ideas and personal questions. In general, they are comfortable with and interested in their use. However, just allowing these learners access to mobile technology is not sufficient to enhance learning, nor educationally ethical. It has to be resourced equitably, and have both the learners and the teachers engaged in processes that enable effective use. Effective utilisation also requires having both teachers and students involved in their ongoing evaluation and dynamic development. Teachers and students need to be influential in the development of apps and the ways they are used in the learning process. If the interrelated pedagogical processes and conceptual thinking are given primacy, then apps can enhance the learning experience and understanding of students. They certainly offer affordances that might transform the attitudes of reluctant teenage students towards learning mathematics.

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