iPads: Improving Numeracy Learning in the Early Years

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The concept of mobile technologies is now an emergent theme in educational research, yet the playing of these edutainment applications and their impact on early childhood learning needs to be fully explored. This study highlights current research and explores how iPads improve student learning. It also examines how the introduction of iPads, affects children's motivation and self-efficacy towards numeracy learning. These findings contribute to the positive use of iPads to foster children's development in numeracy.

There is an ongoing debate about how digital technologies can fit into the educational life of children. "The arguments for and against the use of digital technologies in education ... of young children appear to be concerned with the quality of children's experiences with digital technologies and the value of such experiences for their physical, cognitive and socio-emotional development" (Alliance for Childhood, 2010). This study examined the use of digital devices (i.e., the iPad) and its value in assisting the numeracy development of children in the early years. For this paper numeracy, "the capacity, confidence and disposition to use mathematics" (National Curriculum Board, 2009, p. 5) specifically refers to young children's ability to recognise and quantify numbers 1 to 10.

Play games to learn

In the past decade, there has been an increase in the body of research into digital games and play in all educational age groups, however, very little research focuses specifically on young children. This is of concern as, "play occupies a central role in children's lives" (Isenberg & Quisenberry, 2002, p.33). "Play has long been regarded as a critical element of early childhood curriculum and pedagogy" (Dockett & Perry, 2010, p.715) and acts as an important role in early years mathematics learning (Hunting, 2010). Playing is seen as the core business of young children (Thomas, Warren & deVries, 2010) and an effective vehicle for learning. It is used as a tool to engage children and personalise their learning in a way that is viewed as fun. Play has the potential to advance children's development (Verenikina, Herrington, Peterson & Mantei, 2010), which is why, with improvements in technology in the past decade and the outcry for ever-present computing technology in the classroom, the use of mobile learning devices has become a focus in schools.

Computer games are "the first qualitatively different form of play that has been introduced in at least several hundred years" and "it merits an especially careful examination of its role in the lives of children" (Salonius-Pasternack & Gelford, 2005, p.6). As the iPad is still relatively new, research on its impact in any year level is still in its early stages. For this reason, the introduction of iPads, the next logical step in creating a digital play-based learning environment, has become a current focus in educational research.

Advantages of iPads

As one of the few controlled studies of educational iPad applications (apps) in early childhood, this paper explores its possibilities in enhancing student learning and engagement of children. Although little research has examined the relation between

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learning and iPad apps, there are several reasons to expect that these experiences can foster learning. These include: personalisation of learning; a kinaesthetic, play-based approach to learning; and improved motivation through instant feedback, rewards, and increasing levels of challenge.

Personalisation of Learning

The iPad is a versatile and engaging piece of technology. "The flexibility of the device in terms of purpose and the variety of Apps available, suggest that it is capable of differentiating the learning process for children at different developmental stages, with different needs, and in different contexts" (Mueller, Wood, De Pasquale & Archer, 2011, p.418). The iPad allows us to, "have in our hands a set of mobile tools that can make a difference to personalised learning by providing learning when, how and as you need it." (Murray, 2010, p.4) This allows us to think differently about learning. With iPads, learning can occur in a more personalised way by handing over more control to learners themselves (Stead, 2006). This concurs with research promoting play-based learning where benefits are evident when children have control of their own learning. The iPad allows a child-centred approach to learning by giving them access to apps that cater for individual needs, interests and capabilities (Murray, 2010).

Research has found that mobile devices can have a positive impact on learning experiences for both educator and children (Ng & Nicholas, 2009). As the iPad is portable, ubiquitous, easily accessible and used by many people, it has great potential for learning. Robertson (2009) found that a child's performance in mental maths was significantly enhanced by a cleverly designed handheld game, which also had a positive impact on other aspects of classroom life. Due to these positive results found in mobile technology, "instructional designers are increasingly turning to new technologies and creating learning experiences that leverage the unique interactive features of devices such as the iPad" (Risconscente, 2012, p.3). However, with limited experimental studies on the efficiency of iPads for improving numeracy knowledge, and none of these studies to date focusing on the early years, the importance of this study and its contribution to research on iPads is required.

Kinaesthetic, Play-based Learning

Technological advancements in the ability for participants to physically interact with subject matter have the potential to engage children and enhance learning (Risconscente, 2012). The multipoint touch-sensitive iPad has unique features that can be pinched to zoom and detects when it is moved or tilted, giving it and instructional designers more options for creating effective, interactive learning experiences that move beyond static presentations of most formal schooling teaching techniques. It is perceived that these new technologies, with kinaesthetic features, will assist children to learn. Wilson (2002) found that 'cognitive processes are deeply rooted in the body's interactions with the world'. In other words, children who actively engage using a kinaesthetic approach showed greater cognitive developments. Recent studies have examined 'embodied cognition' in relation to mathematics learning. One study by Alibali & Nathan (2011) found that teachers' and students' gestures were linked to their mathematical understanding. Games in general, contain an element of 'embodied cognition' to create embodied learning experiences and have for a long time been seen as an educational tool enhancing learning. Preschoolers have been shown to gain mathematical knowledge through the playing of board games

(Ramani & Siegler, 2008). Therefore, it is predicted that the iPad, through its game-like apps, has the potential to create play-based learning experiences that are embodied in children's learning, and thus improve their numeracy knowledge.

Motivation

An important consideration with the introduction of the iPad is its affect on a child's motivation. Numerous studies have shown that the motivation of children, especially their self-efficacy (i.e., lack of confidence in their ability to complete academic tasks) is directly linked to achievement levels (Bandura, 1997). Research has also shown that children are more likely to develop long-term interest in subject matter they understand and see as relevant (Risconscente, 2010). "Successfully integrating learning with motivation is a long-standing hallmark of computer-game design" (Risconscente, 2010, p.5). "The games environment offers an engaging environment that is substantially different from that experienced in formal school settings" (Jorgensen & Lowerie, 2011, p. 406) where failure is rarely met with increased enthusiasm. Games are specifically designed where failure and challenge encourage and strengthen a child's motivation upon achieving the end goal.

Mobile learning encourages all learners, especially ESL and reluctant learners, by promoting confidence and independence (Murray, 2010). With lack of motivation and low self-efficacy being some main reasons why these particular children stop trying, it is another benefit for the use of iPads. Children who regularly use mobile learning devices in their learning showed improved attitude towards learning and school in general, as well as having greater engagement and participation in learning (Murray, 2010). This then leads to improved performance. The instant feedback of the iPad also highlights the potential for, "building students' confidence in terms of risk taking and feeling safe to make mistakes and try again, building persistence. This in turn promotes positive affective, behavioural and cognitive engagement" (Attard & Curry, 2012, p. 80).

Research Questions

To accommodate the advancements in mobile learning, the creation of educational games to address learning challenges within different learning areas has surged over the last decade (Habgood & Ainsworth, 2011). Although numerous apps on the market claim to improve educational needs, to date limited controlled studies have been conducted to evaluate their effectiveness. This study explored a numeracy app and its effectiveness in improving the numeracy learning of young children.

The literature illustrates that iPads can have a positive impact on children's numeracy learning, however most studies to date have focussed on: (a) secondary and tertiary students and not investigated the early years of schooling; and (b) how iPads increase children's engagement but neglect the impact they have on cognition. For this reason questions arose to the effectiveness of iPads in the early year's context. The main question was: Why introduce iPads? These were followed by: How does the introduction of iPads impact on numeracy learning in the early years? (Is it a valuable tool in numeracy learning?); and How does the introduction of iPads impact on the motivation of children in learning numeracy? (Are children from this play-based enriched environment of learning, motivated to learn numeracy with iPads?).

Methodology

Participants: This study was conducted at a private school in Dubai, United Arab Emirates. The study occurred in Foundation Stage 2, which has eight classes of approximately 160 students. These students turn five during the school year. The school was given the opportunity to engage in current technology practice by introducing iPads. Sixteen of these were solely dedicated to the eight classes (2 per room) to investigate their potential in this play learning enriched environment. With the introduction of iPads into the curriculum, many questions arose to its validity, which in turn prompted this paper.

Design: This study implemented a type of repeated-measures design, known as the crossover approach. Crossover studies use controlled experiments and are commonly used in scientific disciplines like education (Howell, 2009). In this type of study the covariates are measured at the beginning of the study and again after each, equal length treatment period. An advantage of this type of design is it exposes every subject to the intervention, while the disadvantage is the 'carry over effect' where the earlier treatment may affect the current period (Jones & Kenward, 2012). For this study, the treatment period consisted of iPad usage for two 10 minute sessions a day, over five consecutive days. The control period had no i Pad interaction, but continued with normal class numeracy lessons. Teachers did not give any time to teaching digit formation. By having both groups take part in the experimental and control groups, it is more likely to isolate the effect of iPad usage without ethical issues arising due to unfairness amongst classes. Table 1 show the testing procedure used in this design. For the first half of the study, Group 1 served as the experimental group with iPad usage, while Group 2 was the control group. At the midway point, it was predicted that Group 1 should show greater improvement than Group 2. By the conclusion of the study it was predicted that Group 2, once exposed to iPads, should show the same improvement.

Table 1
Testing Procedure

Group	Day 1	Day 1-5	Day 6	Day 6-10	Day 11
Experimental Group 1	Pre-test	iPads	Mid-test	no iPads	Post-test
Experimental Group 2	Pre-test	no iPads	Mid-test	iPads	Post-test

iPad Application: The numeracy application used was "Know Number Free" by Lookkid Software. This application is aimed to help children of all ages learn to recognise and count numbers. It also provided practice in tracing and writing numbers to 10. Once the lessons on r ecognising and counting are completed, access to number games and activities are unlocked. These games are only unlocked once the child masters each skill. This app was chosen for two reasons: a) it's a simple app with clear visuals relating digits to a number of objects and numerals; and b) digit formation was a skill highlighted by the teachers that needed improvement.

Materials: The numeracy assessment consisted of writing the numerals from 1-10 as was focussed on in the app. The children were told a number and asked to write the numeral that represents it. During the assessment reversal were marked as incorrect. In addition, a four question, three-point Likert scale attitude questionnaire was used to measure children's motivation and self-efficacy. The Likert Scale was represented by a smiley face, a straight face and a frown. Each question was read out loud by the researcher under the same conditions for each group of children. Children were asked to colour in the

smiley face that best represented them. Example of questions included: "I like learning about numbers' and 'I enjoy using iPads to learn numeracy". An informal group discussion occurred with the teachers following the testing periods.

Results

A one-way repeated measures ANOVA was conducted to compare the scores of children's numeral writing, with a Pre-test, Mid-test and Post-test. Table 2 and 3 present the descriptive statistics for the two groups. Group 1 showed a significant effect over the time periods, Wilk's Lambda = .66, $F\ (2, 56) = 14.76$, $p < .0005$, multivariate partial eta squared = .35. Group 2 descriptive statistics also showed that there was a significant effect over the time periods, Wilk's Lambda = .69, $F\ (2, 54) = 12.22$, $p < .0005$, multivariate partial eta squared = .31.

Table 2
Descriptive Statistics for Experimental Group 1

	N	Mean	StDev
Pre-test	58	7.172	2.429
Mid-test	58	8.293	1.757
Post-test	58	8.155	2.007

Table 3
Descriptive Statistics for Experimental Group 2

	N	Mean	StDev
Pre-test	56	7.196	2.400
Mid-test	56	7.000	2.071
Post-test	56	8.107	1.713

To find where significant differences occurred for each group, Pair-wise comparisons with Bonferroni adjustments for multiple comparisons were used. Group 1 results revealed a significant difference between the pre-test and mid-test results (mean difference = 1.121 with significance .000) but no significant difference between the mid-test and post-test results (mean difference = .138 with significance 1.000). By contrast the Pairwise Comparison of Group 2, revealed that while no significant difference existed between the Mid-test and Post-test results (mean difference = .196 with significance 1.000), there was a significant difference between the Mid-test and Post-test results (mean difference = 1.107 with significance .000). As hypothesised, the results demonstrated that Group 1 showed significant improvement in their numeracy learning, once exposed to iPads (between pre-test and mid-test). This learning was maintained during post-tests and not lost over the period without iPads (between mid-test and post-test). For Group 2, only after their exposure to the iPads was there a significant improvement. To examine the extent of the differences between these two groups a Two-sample t-test was used to analyse the results. The results indicate that the groups did not differ significantly at the pre-test (p-value = 0.958). Consistent with the hypothesis, Group 1 who used iPads in their learning first, showed significant improvement compared to Group 2 by the Mid-test (p-value = 0.000). On completion of the post-test, both groups were again equivalent with no significant difference between them (p-value = 0.891). While results showed that children had some

concept of digit recognition and formation before the introduction of iPads (pre-test of 7+), statistically significant improvements were made after their use. Most children had difficulties with the reversal of digits, particularly '2' and '5' in the pre-test and mid-test assessments, while the reversal of '3' and '9' remained errors in post-tests. Further investigation into problematic digits would be beneficial. The use of iPads improved children's reversal of digits.

A one-way repeated measures ANOVA was conducted to compare the scores on the attitudes survey. The analysis of this produced results with no significant difference. Children had high motivation scores throughout the study. A limitation of this dimension of the study was that only four questions were asked and a three-point rather than a five-point scale was used. It is also noted that scales of the questionnaire were all positively stated and children of this age are inclined to agree with statements. Future investigation into the motivation and attitudes of students could be examined by using multiple indicators of a variable (i.e., more questions related to the same item). These results may also show that children in the early years are already exposed to a play-based context and therefore may be more engaged naturally at this stage of development. Future studies, an increased number of valid items could provide further insights into the relationship between the use of iPads and children's affective domain.

Discussion

The results of this study show that the introduction of iPads can improve children's numeracy learning. It is conjectured from the results of this small pilot study that it is a valuable tool and resource to be utilised in numeracy learning. The data provides evidence that a week of daily exposure to iPads improved numeracy and that this type of digital play advanced children's development in recognising, writing and quantifying numbers.

The literature discussed the possibility of iPads improving children's cognition through personalisation of learning. Although this study focussed only on one particular iPad app, teachers noted that high achieving students found this app, "boring," as it didn't match with their abilities, highlighting the need for informed choices when selecting digital applications. This was also noted in Attard & Curry's (2012) study on i Pad implementation, where the "importance of teacher supervision and management skills as well as the importance of being aware of individual students' capabilities" (p. 80) was essential. Attard & Curry (2012) also stated that, "The integration of the iPads highlighted the need for teacher professional development" (p. 75). This was evident in teacher's own perceptions of iPad usage in the classroom. Many saw them as another tool available but didn't feel confident in their use, especially integrating into their teaching pedagogy. As with any new resource introduced into the classroom, the appropriate training and support needs to be implemented to ensure its effectiveness. Just as teachers need professional development, children need to be taught explicitly how to use iPads as an effective tool for their learning. Teachers from this study noted that at times students would incorrectly use the app, showing the importance of modelling the app before use, as well as discussing appropriate behaviours when using iPads. Parents of Verenikina & Kervin's study (2011) noted the necessity to assist the children with the technologies at least in the beginning of their use. Other studies have noted that, "instructors may play a key role in helping students to realize the potential that technologies have in the traditional classroom learning environments and beyond" (Mueller, Wood, De Pazquale & Archer, 2011, p.419).

Review of current research, showed the possibilities of iPads to create 'embodied cognition' to enhance children's learning. The embodied nature of the iPad, with its ability

to produce unique, play-based learning experiences is a key consideration into their effectiveness. By physically interacting with the device, and repeatedly completing tasks, students were assisted in improving digit formation and number recognition. The effectiveness of iPads as a tool allows learning to move beyond static presentations normally used in teaching by helping children achieve mastery and automaticity. In this study, children's numeracy ability was enhanced through these features. Participant teachers noted that children who normally experienced learning difficulties were more likely to engage in the game play of iPads and gained confidence, even when making mistakes. The challenge of completing strengthened their motivation to persist and, thus improve their numeracy skills. The study did not compare iPads to traditional classroom instruction or other manipulative tools. It also did not explore other educational apps. Therefore, conclusions on the effectiveness of iPads in comparison to other teaching methods, deserves investigation.

Conclusion

The data reported here provided evidence that a week of daily exposure to iPads resulted in significant numeracy leaning gains in number recognition and digit formation. The iPad games helped children practise and learn numeracy concepts. Importantly, the benefits accrued by the first group were not lost after several days of non-exposure to iPads. Therefore it is reasonable to conclude that the gains made were stable, at least in the short term. In conclusion, iPads are a valuable tool to use in the learning of mathematics. As Attard & Curry (2012) found, "the introduction and integration of iPads into mathematics teaching and learning appears to have had a positive impact on the teaching and learning of mathematics" (p.81). This study highlighted children's eagerness to use iPads during numeracy lessons, and how using it as a resource improved achievement levels. The kinaesthetic and play-based learning had a positive relationship on student numeracy learning. The findings of this study also suggest that further investigations into the use of iPads to teach and learn numeracy and its affect on student motivation are necessary, especially the 'novelty' factor of these new devices. Future studies into app choices and the integration of iPads into teaching pedagogy would also be beneficial. Arguments over the effectiveness and impact of these current mobile technologies on student learning have lead to much debate. The most important to note is that, "Digital media are here to stay and are going to be widely used by young children. The important issue is how to maximize the positive consequences of these new media so that they enrich rather than hinder children's play experiences" (Johnson & Christie, 2009, p. 285).

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