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Closing the gap: Efficacy of a tablet intervention to support the development of early mathematical skills in UK primary school children

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ABSTRACT

The efficacy of a hand-held tablet technology intervention with learner-centred interactive software aimed at supporting the development of early maths skills was evaluated in four studies conducted in three UK primary schools. Immediate and sustained gains in mathematics were determined by comparing maths performance before, immediately after, and 5-months after the intervention. The impact of the child's first language, socio-economic status and basic cognitive skills (non-verbal intelligence, memory, processing speed and receptive vocabulary) on learning gains was also explored. In total, 133 pupils aged 4–7 years took part. Class teachers implemented the maths intervention for a specified period of time. Results showed significant immediate and sustained learning gains following the intervention, particularly for children identified as low-achievers. No significant effect of child's first language or socio-economic status was found but children with weaker memory skills demonstrated stronger learning gains. Overall, these findings indicate that tablet technology can provide a form of individualised effective support for early maths development, when software is age appropriate and grounded in a well-designed curriculum. Apps that incorporate repetitive and interactive features might help to reduce cognitive task demands, which could be particularly beneficial to low-achievers and could help to close the gap in early maths attainment from the start of primary school.

1. Introduction

Raising standards in mathematics education in the United Kingdom is an issue of national importance. In the latest PISA assessment of 15-year olds' maths ability, the UK ranked 27th out of 34 participating countries (Organisation for Economic Co-Operation and Development [OECD], 2016). Furthermore, a '*stubborn-tail of underachievement*' is evident amongst disproportionate groups of underachieving pupils in the UK (Tymms & Merrell, 2007). Research shows children with low socio-economic status (SES), which considers the levels of income, employment and deprivation in an area, and children who have English as an additional language (EAL), have significantly lower mathematics ability levels compared to their peers (Anders et al., 2012; Denton & West, 2002).

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To address underachievement in mathematics potential solutions need to engage children from a young age. Research shows early learning experiences are a significant predictor of attainment at the end of primary school (Sylva, Melhuish, Sammons, Siraj-Blatchford, & Taggart, 2010). Children considered to have developed well through the first year of primary school, known in the UK as the Early Years Foundation Stage (EYFS), exceed expected numeracy and literacy levels three years later (Department for Education [DfE], 2010). Conversely, children who progress slowly and exhibit low attainment levels at the end of the EYFS are six times more likely than children who progress at a typical rate to be in the lowest fifth of achievers three years later, at the end of the early primary years (Department for Children, Schools and Families [DCSF], 2008). Therefore, it is vital for all children to develop a strong early foundation in mathematics, particularly those vulnerable to underachievement.

A potential pedagogical approach to support the development of early mathematical skills in the first years of primary school is combining play and technology. Technology-based educational games have the potential to have a positive impact on early education through their capacity to address the differing abilities of individual children. Software features including multiple representations of information, such as pictures, video, and animation, varying levels of task difficulty, clear goals and rules, learner control, task feedback and repetition, serve to create an individualised learning environment, placing the child in active control of their learning (Condie & Munro, 2007; see also; Rose, Meyer, & Hitchcock, 2005). Furthermore, hand-held tablet technology devices are light-weight, eliminate the need for dexterity reliant additional devices (e.g. keyboard and mouse), and have the capacity to store multiple child-friendly educational applications (Kucirkova, 2014). Coupled with well-designed, curriculum-based, child-centred software, tablet technology interventions have the potential to embed learning through play and thus could provide a useful classroom aid to supplement early years teaching.

In this study, we evaluated the use of hand-held tablet technology with learner-centred software in supporting children's early maths skill development. The software is based on the UK maths curriculum for the first year of primary school and is designed for use with hand-held devices, such as Apple iPads or Android tablets. Such advances in hand-held technology have the potential to offer learner-centred support in developing early mathematical skills during the early years of primary school but require formal evaluation for their efficacy to be shown.

The current evidence base surrounding the use of tablets in schools is limited and fragmented (Haβler, Major, & Hennessy, 2016), particularly in mathematics (Cheung & Slavin, 2013) and early education. To date, four studies have been published, which have examined the use of technology-based educational mathematics games with children in the first 3 years of primary school (EYFS to year 2) or equivalent, which are reported in sufficient detail to allow objective comparison using effect sizes (Cohen, 1988). The studies compared technology-based educational maths games either to normal practice (Pitchford, 2015; Praet & Desoete, 2014; Räsänen, Salminen, Wilson, Aunio, & Dehaene, 2009) or a non-technology based maths game (Shin, Sutherland, Norris, & Soloway, 2012). For each of these studies we calculated within-group effect sizes across the intervention period and found size of effect to range from large (Cohen's $d > 0.8$, Pitchford, 2015; Praet & Desoete, 2014), to medium (Cohen's $d > 0.5$, Shin et al., 2012) to small-medium (Cohen's $d > 0.4$, Räsänen et al., 2009). It is noteworthy that the study with the largest effect size (Pitchford, 2015) also implemented the intervention for the longest duration (20 h), suggesting that time-on-task is a contributing factor on the extent of learning gains observed. Whilst effect sizes vary across studies, overall, these studies demonstrate the positive impact of technology-based educational games in supporting mathematical development in young children, particularly in low-achieving pupils (Räsänen et al., 2009; Praet & Desoete, 2014). However, no study to date has investigated how additional factors known to influence scholastic progression, such as, SES and EAL status and basic cognitive skills, impact on the effectiveness of technology-based maths interventions implemented in early education.

This study reports the first UK evaluation of a tablet-based maths intervention for pupils in the first years of primary school. The intervention consists of learner-centred progressive software delivered via hand-held tablet technology. The intervention has been shown to be effective in supporting early mathematical skills in primary school children in Malawi (Pitchford, 2015), a low-income country in sub-Sahara Africa. The Malawi evaluation study used the same set of interactive apps evaluated here, but adapted for an African context and delivered in the local language of Chichewa. Whilst this intervention has been shown to be effective in Malawi, it is not yet clear if it will be effective in a high-income country, such as the UK, where hand-held tablets are ubiquitous and children receive structured tuition in maths from the start of primary school. Here, we report a series of four studies that evaluated the intervention with UK primary school children, as implemented by class teachers and delivered in English. Together these studies address key questions that are needed to provide proof of concept that this intervention can be effective at supporting the development of early maths skills in children aged 4–7 years old in an UK educational setting. First, to determine if the intervention works in a UK context, we examined immediate and sustained learning gains in maths for children across variable periods of intervention by comparing maths performance before, immediately, and 5-months, after the intervention. Second, to determine the suitability of this intervention for children from different backgrounds we explored the impact of the child's first language, socio-economic status, and basic cognitive skills (non-verbal intelligence, memory, processing speed and receptive vocabulary) on learning gains in maths across the intervention period.