Mobile educational applications for children: what educators and parents need to know

Stamatios Papadakis* and Michail Kalogiannakis

Department of Preschool Education,
Faculty of Education,
University of Crete,
Crete, Greece
Email: stpapadakis@gmail.com
Email: mkalogian@edc.uoc.gr
*Corresponding author

Abstract: The popularity of smart mobile devices is growing fast. These digital devices represent a new generation of technological tools that offer remarkable access to content as well as opportunities for creative use even by young children. Most the best-selling paid apps in the education category are targeted towards children. At the same time, the educational value of those applications is difficult to be determined. Parents and educators, who are turning to those devices for the potential educational benefits they expect for their children and/or their students, have a limited number of tools with which to evaluate these apps. With regard to the literature review, we present the latest findings related to the real educational value of these 'self-proclaimed' educational apps. Our analysis concludes that while there are thousands of apps available today, choosing the most appropriate educational ones for children is difficult and problematic for both teachers and educators.

Keywords: smart mobile devices; tablets; educational apps; preschool age children; early childhood education.

Biographical notes: Stamatios Papadakis is a graduate of the Economics and Business (AUEB) University, Athens, Greece, Department of Information. He received an MSc in Education from the University of the Aegean, Greece, and a PhD from the University of Crete, School of Education. He has been working for a series of years as an ICT teacher in public sector secondary education. He has published many articles in journals and has presented several papers in conferences. His research interests include ICT in education, mobile learning, novice programming environments and teaching of programming in primary and secondary education.

Michail Kalogiannakis is an Assistant Professor in the Department of Preschool Education at the University of Crete and Associate Tutor at School of Humanities at the Hellenic Open University. He has graduated from the Physics Department of the University of Crete and continued his postgraduate studies at the University Paris 7-Denis Diderot (DEA in Didactic of Physics), University Paris 5-René Descartes-Sorbonne (DEA in Science Education) and

received his PhD degree at the University Paris 5-René Descartes-Sorbonne (PhD in Science Education). His research interests include science education in the early childhood, science teaching and learning, e-learning, the use of ICT in education, distant and adult education. He has published many articles in international conferences and journals and has served on the program committees of numerous international conferences.

1 Introduction

Children are in the midst of a vast, unplanned experiment, surrounded by digital technologies that were not available but 5 years ago (Hirsh-Pasek et al., 2015). Mobile touchscreen technologies also referred to as tablet technologies (Goodwin, 2012) are revolutionising the interactive digital experiences of young children (Chiong and Shuler, 2010; Papadakis and Kalogiannakis, 2010; Zaranis et al., 2013; Hung et al., 2014a; Hung et al., 2014b; Chen et al., 2014; Hwang et al., 2015). Owing to the growing inclusion of touchscreens, 'the days of the mouse keyboard and desktop graphical interface are numbered' (Waters, 2009).

Young children explore and learn with mobile devices in ways that are natural to them (touch, repeat, trial and error) (Cohen et al., 2011, p.3). The reason is that touchscreen devices (tablets) are designed in such a way that even very young users can use them easily (Papadakis et al., 2017). Early research findings show that children younger than 2 years old can play and learn using mobile devices and/or multitouch displays (Michael Cohen Group LLC, 2011). Other studies revealed that children as young as two will naturally interact with a touchscreen, in the same way they will use natural instincts to play with a new toy (Sharkins et al., 2015). A study across Australia, New Zealand, the USA and Britain found more 2–5-year-olds are able to manipulate apps than tie their shoelaces or ride a bike (Grose, 2013). Preschool children do not need to develop the manual handling skills to use a separate keyboard and mouse required by general-purpose computers (Olney et al., 2008) in order to gain access to interactive content designed specifically for them (Plowman, 2012; Highfield and Goodwin, 2013; Papadakis et al., 2016a; Papadakis et al., 2016b; Papadakis et al., 2016c).

At its best, touchscreen technology offers a mode of interactive experience that mirrors the child's natural constructivist learning (Papadakis and Orfanakis, 2014; Orfanakis and Papadakis, 2014). Ideally, smart devices accompanying applications (apps) can create exciting and effective learning environments for learning and instruction in early childhood (Goodwin, 2012; Papadakis et al., 2016b). Developers are increasingly creating educational apps that target this age group (Hiniker et al., 2015). A content analysis in the 'Education Section' of Apple's app store, conducted by Shuler in 2009, found that almost half (47%) of the top 100 selling apps targeted preschool and primary school age children. Mathematics and literacy apps were the most popular categories of apps (Shuler, 2009a). In a study conducted in 2012, the same researcher found that the number of apps which targeted preschool and primary school age children increased to 72% from 47% in 2009 (Shuler, 2012). In the Android Operating System, educational apps are among the top four categories of apps most accessed by the users and rank third in terms of a total number of paid apps being purchased by users (Avtar, 2014).

Currently, there are few examples of well-designed educational apps for young children (Hirsh-Pasek et al., 2015). The selection of the right app is very important as it can make the difference between the 'digital babysitter' and the tool to support children's learning and development (Goodwin, 2013). As many of the self-proclaimed educational apps are very entertainment-oriented due to several reasons they lack an educational impact on child cognitive development (Yusop and Razak, 2013). Although some parents are advanced and knowledgeable technology users themselves, this does not mean that they necessarily understand the full implications of the ICT products and services when used by young children (Ebbeck et al., 2016, p.2). At this point, the problem of the selection of the appropriate technologies such as apps that facilitate active and creative use by children (NAEYC, 2012) is becoming bigger and bigger for both parents and educators. As not all apps are of the same quality, it is also important to note, cost does not necessarily correlate with quality (Bouck et al., 2016).

Given the absence of an industry standard or an official rating system for children's apps, websites or blogs are frequently consulted when choosing apps by parents and educators (Crescenzi-Lanna and Grané-Oró, 2016). However, this selection method is problematic too, and the reason is that the majority of those blogs and websites use a methodology for the assessment of 'educational' apps for children, which is lacking in terms of quality, and does not meet age-appropriate and other pedagogical standards (Crescenzi-Lanna and Grané-Oró, 2016).

2   Children and smart mobile devices

Today's children are increasingly using a range of touch devices like smart boards, smartphones, tablets, iPods, e-toys and more to play, learn and communicate in new ways (Goodwin, 2013) and spend a great deal of time in front of screens (Papadakis et al., 2014). This encompasses both foreground and background media (Epstein, 2015). Recent research findings show an increase in tablet ownership and usage among very young children. Since the introduction of the first tablet device (iPad) in 2010 by Apple, the popularity of tablets has grown rapidly among young children (Common Sense Media, 2013). According to a Nielsen survey of adults with children under 12 in tablet-owning households in the USA, 70% of children share a tablet with family members. 77% of those surveyed said children play downloaded games on their tablets and 57% said children used tablets to access educational apps (Nielsen, 2012). Crescenzi-Lanna and Grané-Oró (2016) state that a study entitled 'Kids and CE' from the NPD Group in 2014 revealed that more than 70% of families with children owned smartphones and tablets in the USA, when in 2012 it was no more than 55%, and in the case of tablets the number had doubled in 2 years. Ebbeck et al. (2016) in a study in Singapore that included 1.058 adult participants, which were parents/caregivers of 1.559 children below 7 years of age, found that tablets were the most popular technological devices used daily by children aged under 7 years. Summary points of the study were that 3-year-olds spent the largest amount of time on smartphones, on average, 6 hours per day, while 5-year-olds spent the largest amount of time on touchscreen devices (0.6 hours daily).

A key reason for the popularity of smart mobile devices among children is related to technological features of these devices (Papadakis, 2016). Large screen displays, high resolution, lightweight, user-friendly and ergonomic design, short start-up time, multimedia content viewing ability, are just to name a few (Papadakis et al., 2016).

Additionally, smart device mobility and ease allow children to learn in a variety of settings instead of the traditional desk and chair (Ellingson, 2016). Those features permit children the flexibility of laying the tablet in their lap, on the floor or moving with it to any area within their home (Wood et al., 2016). Especially useful for preschool-aged users are certain characteristics of tablets, such as the automatic screen rotation to landscape or portrait mode based just on how they are holding the device, the multitouch options and the ability to interface with the device using alternative gestures (moving an object either by touching a point on the screen or by dragging it), movements that do not need the help or guidance of an adult (Crescenzi-Lanna and Grané-Oró, 2016; Geist, 2012). Activity in the context of smart mobile devices can take a number of forms. For example, children can touch the screen (e.g. poke, swipe, pinch), move the device (e.g. shake, tilt, point), talk or sing into the microphone, listen to music through speakers or headphones, and wave for a camera connected to gesture-recognition software (Hirsh-Pasek et al., 2015, p.10). Additionally, smart mobile devices do not require the variety of separate peripheral devices used for computer input such as a mouse, trackball, touchpad, trackpoint and keyboard (Bayles and Knoke-Staggs, 2013).

Consequently, as smart mobile devices have become one of the most popular media used by young children the image of preschool and primary school children (Zaranis, 2016) using and sharing their mobile devices with parents, siblings, or other members of family becomes more familiar (Madden et al., 2013), a phenomenon known as 'pass-back effect' (Chiong and Schuler, 2010). It is not a coincidence that interactive tablet styluses toys and products for toddlers are already available from the major toys companies worldwide such as Apptivities from Mattel and Appmates from Disney (Bayles and Knoke-Staggs, 2013).

3 Smart mobile devices in early childhood education

Although Apple in 2010 did not introduce the iPad as an educational tool, it has found its way into classrooms across the world. Digital devices are part of the culture in which children grow up; they permeate children's home and school life (Zaranis, 2013). As a result, our society puts pressure on educators and parents to provide digital literacy to young children (Pearsall, 2014). iPads and other forms of tablets are becoming commonplace in schools today, as they are regularly used for teaching. According to the World Bank, educational policy-makers are authorising the purchases of tablets in many education systems around the world as those devices are seen as powerful and iconic symbols of modernity within an education system (Trucano, 2015). In the UK, at the end of 2014, over 70% of all primary and secondary schools had tablet devices in their classrooms and 900,000 tablets were expected to be in schools by 2016 (Coughlan, 2014).

In classroom settings, tablets are better than interactive whiteboards, whose fixed position often rendered them inaccessible for children reliant on wheelchairs and other physical supports (Flewitt et al., 2014). Lynch and Redpath (2014) in their research found that learners as young as 2 years old can use iPads independently and Beschorner and Hutchison (2013) also demonstrated that young learners are able to navigate the iPad on their own. As research suggests, children as young as 4 years old find it difficult to use a mouse and especially the use of the left button (Crook, 1992). If children cannot use educational technology effectively, they certainly cannot learn (Muller, 2002). Even

5-year-old children may encounter difficulty ending an activity using the mouse (Hourcade et al., 2004). The research of Abdul Aziz et al. (2013) shows that all children of age 4 and onwards can use the seven common gestures such as tap, drag-and-drop, slide, pinch, spread, spin/rotate and flick, which mobile applications generally require for usage.

The rapid influx of new screen devices poses a special challenge for the early childhood community (Campaign for a Commercial-Free Childhood, Alliance for Childhood and Teachers Resisting Unhealthy Children's Entertainment, 2012). Early Childhood Educators (ECEs) are beginning to think about the role of this new technology in their classrooms and many preschool programs are beginning to purchase tablets, for classroom use (Beschorner and Hutchison, 2013). One of the reasons is that smart mobile devices provide 'significant opportunities for genuinely supporting differentiated, autonomous, and individualised learning' (Shuler, 2009b). Previous research supports that the developmentally appropriate use of technology can encourage the cognitive and social growth of young children (Beschorner and Hutchison, 2013). Touch devices present unique opportunities for enhancing young children's understandings of abstract concepts through the presentation of dynamic representations, opportunities for embodied learning and the inclusion of interactive elements (Goodwin, 2012). Yelland and Gilbert (2011) found in a study they conducted that the use of tablets across three different settings with children aged from 2 to 6 years of age represents a viable learning context in different ways for the children involved. Other emerging studies from the USA and Australia have shown that young children's learning can be enhanced using real 'educational' apps (Goodwin, 2013). These mobile devices and their accompanying apps can enhance knowledge acquisition through three different learning styles (VAK learning style): (a) visual, (b) acoustic, and (c) kinaesthetic (or physical, tactile) learning (Beeland, 2002).

In 2012, the National Association for the Education of Young Children (NAEYC) stated that they encourage children from birth to 8 years of age to use tablets and age appropriate educational apps to support early literacy development (Ellingson, 2016). In ECE tablets can provide fun activities to allow children to articulate their creative perspectives; foster interest in the research process; and offer a route towards informed consent (Arnott et al., 2016). Findings also indicate that there are several types of learning that occur during app play. These include the tacit learning of the game and how it works; mastering of explicit learning tasks (e.g. matching, counting) embedded in the game narrative; and the use of skills and models learned and applied to other types of games and levels of play. Engaging with creative app activities often shifts the child's focus away from the subjective experience of winning or losing to a personal best competition (Cohen et al., 2011). While there are thousands of apps available today, choosing the most appropriate educational ones for children is difficult and problematic for both teachers and educators.

4   Mobile applications (apps)

At the apex of the boom of smart mobile devices is the introduction of applications (apps) for tablets and smartphones (Hirsh-Pasek et al., 2015). Various researchers mention that besides the technological features of the smart mobile devices, these are in favour of young children mostly due to the existence of mobile applications specially

designed for these devices (Zaranis et al., 2013). Research has revealed that young children are very engaged with the apps and love to play with them for various amounts of time depending on their needs and interests and the content and structure of the app (Yelland and Gilbert, 2011). A mobile application is a computer program designed to run on mobile devices such as smartphones and tablet computers (Yusop and Razak, 2013; Wikipedia, 2016; Bouck et al., 2016). A mobile application may also be known as an app, iPhone app or smartphone app (Techopedia, 2016). Goodwin (2013) states that there are more than just 'paid' and 'free' apps in the app stores. There are in fact five different types of apps (see Figure 1).

According to their pedagogical dimension, various researchers have tried to categorise apps designed for children in different categories depending on their open- or close-ended character, their level of activity, etc. Goodwin (2012, p.12) distinguishes apps into three different categories:

- Constructive or 'productivity' apps, which are characterised by an open-ended design that allows users to create their own content or digital artefact using the app. Constructive apps are designed for creative expression.

- Instructive apps have elements of 'drill-and-practice' design whereby the app delivers a predetermined 'task' which elicits a homogenous response from the user. These apps require minimal cognitive investment on behalf of the learner. Most game apps are classified as instructive apps.

- Manipulable apps allow for guided discovery and experimentation within a predetermined context or framework. These apps require more cognitive involvement than instructive apps but less than constructive apps.

Respectively, according to Cohen et al. (2011, p.9) the 'world of apps' currently designed for children includes three general types: gaming apps, creating apps and e-books.

- In gaming apps, the activity includes a range of challenges, actions and reactions that lead to skill acquisition and achievement as levels are played and mastered.

- In reading apps or e-books, the story or the reading of the story is the activity. Playful features or mini activities are integrated into a familiar schema of reading a book. The curriculum is in this context either explicit in the text or implicit and embedded in the activities.

- Creating apps provide tools, workspace and activities (e.g. cupcakes, robots, painting, etc.).

Research suggests that children learn best when they are cognitively active and engaged, when learning experiences are meaningful and socially interactive, and when learning is guided by a specific goal (see Figure 2) (Hirsh-Pasek et al., 2015). Additionally, children progress quickly from novice to mastery when using a well-designed app (Cohen et al., 2011, p.3). The majority of apps in today's marketplace can be considered part of the 'first wave' of the digital revolution (Hirsh-Pasek et al., 2015). In this wave, apps are simply digital worksheets, games, and puzzles that have been reproduced in an e-format without any explicit consideration of how children learn or how the unique affordances of electronic media can be harnessed to support learning (Hirsh-Pasek et al., 2015).

Figure 1   The five different types of apps
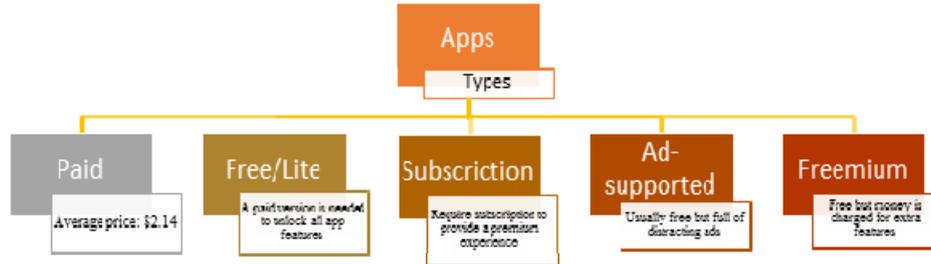
Source: Adapted from Goodwin (2013)

Figure 2   The four pillars of an educational app
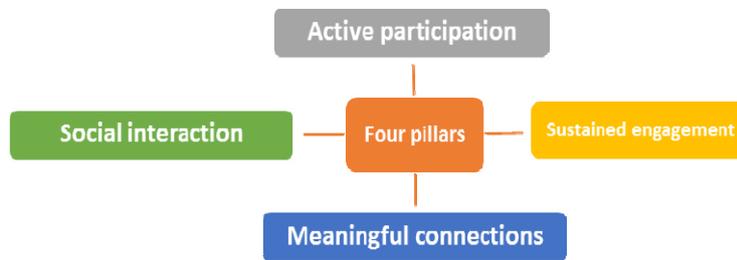
*Source:*   Adapted from Hirsh-Pasek et al. (2015)

5   The app marketplace

Mobile applications have turned into a quick enrichment tool for the software industry. Since its entrance into the iPhone business in 2007 (the first smart mobile device with touchscreen), the mobile app industry business has matured and has become part and parcel of the economy itself (Dogtiev, 2015). This rapidly expanding mobile-app industry is worth billions of dollars (Nielsen, 2012). Apple's digital app store, called App Store, opened for the first time on 10 July 2008, providing free or paid applications for iPhone, and later for iPod touch and iPad devices. In 2011, more than 2.5 billion dollars were 'paid' to the software industry (Rideout, 2011) while in 2014 apps generated over 10 billion dollars in revenue for developers (Apple, 2015). As Apple's CEO stated, at the end of 2014, users had downloaded 75 billion applications and had visited the App Store 300 million times per week (Perez, 2014). Three models, paid, in-app purchase and advertising, power the mobile app business. Total app revenues are projected to grow from 45.37 billion dollars in 2015 to 76.52 billion dollars in 2017. In 2012, in-app purchases accounted for 11.4% of global mobile app revenues and are expected to grow to 48.2% in 2017. In-app purchase revenues will reach 28.9 billion dollars by 2017 (Dogtiev, 2015).

According to a report of the Federal Trade Commission (FTC), an independent agency of the US government, entitled 'Mobile Apps for Kids: Current Privacy Disclosures Are Disappointing', smart mobile devices users in 2008 could choose from

about 600 apps (Mohapatra and Hasty, 2012). In 2012, there were more than 500,000 apps in the Apple App Store and other 380,000 in Google Play (the digital distribution platform for mobile apps on the Android Operating System). As of June 2015, 1.5 million mobile apps were available in the Apple App Store (Statista, 2016a). Accordingly, the number of available apps in the Google Play Store, formerly known as Android Market, surpassed 1 million apps in July 2013 and was most recently placed at 2 million apps in February 2016 (Statista, 2016b). Figures 3 and 4 give information on the number of available apps in the Apple App Store and Google Play Store since July 2008 and December 2009.

Figure 3 Number of available apps in the Apple App Store (see online version for colours)
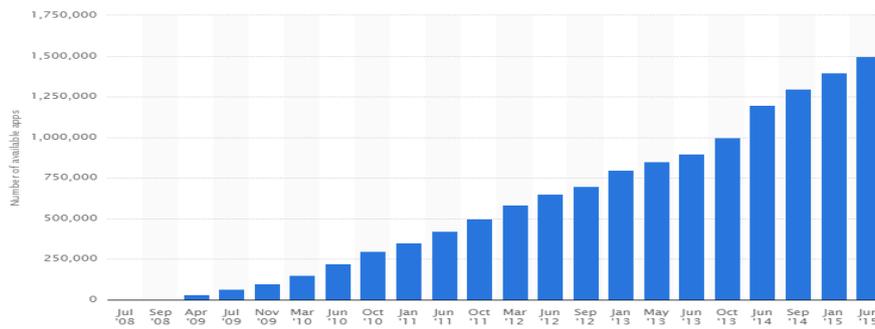
Source: Statista (2016a)

Figure 4 Number of available apps in the Google Play Store (see online version for colours)
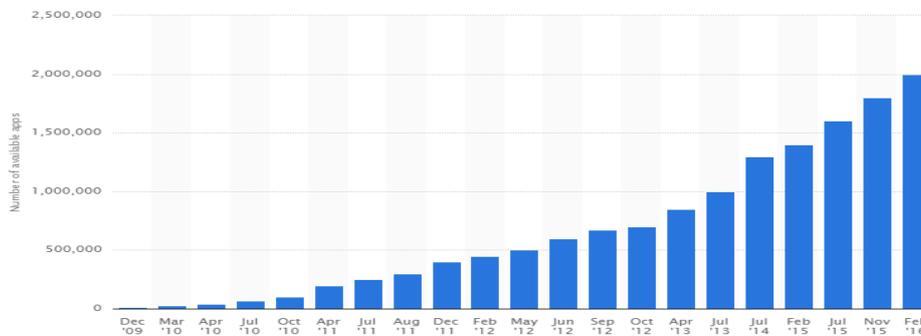
Source: Statista (2016b)

Beginning in infancy, screen technologies dominate the lives of many young children (Campaign for a Commercial-Free Childhood, Alliance for Childhood and Teachers Resisting Unhealthy Children's Entertainment, 2012) and there has been a rush to fill this new space (Donahoo, 2012). The market for apps for children has emerged as apps for preschool and primary school age children are gaining children's attention due to their attractive graphical and interactive elements (Robijt and Van den Broeck, 2013). As children become more familiar with new technologies, target marketing of this particular age group with new products is inevitable. Developers of all sizes in their turn aim at the

educational category and the design and development of applications that are targeted at children under 8 years old (Crescenzi-Lanna and Grané-Oró, 2016). Especially the educational app market is a continuously growing industry and becoming one of the few sectors whose numbers improved every year (Cardenal and López, 2015). As children of all ages have embraced smart mobile devices for entertainment and educational purposes they browse and download thousands of apps everyday either paid or free (Mohapatra and Hasty, 2012). In the middle of 2013, the Apple announced a new Apple Kids Store for children under 12 years old. Apps compliant for this category must be made specifically for kids ages 5 and under, ages 6–8, or ages 9–11. As Apple states, the company's aim is to provide 'parents with a place to find age-appropriate apps for their children' (Zytnik, 2014). Figure 5 shows the number of cumulative app downloads from Apple's and Google's App Store from July 2008 to June 2015 (Satish, 2015).

Figure 5   The number of cumulative app downloads from Apple's and Google's App Store from July 2008 to June 2015

Source: Satish (2015)

6   The necessity of developing standards for mobile design and development

The selection of appropriate mobile applications is of particular importance, as developmentally appropriate apps can support children's learning (Bennett, 2011). The quality of mobile applications targeted at early childhood depends on two conditions: taking into consideration the developmental stage of the child when formulating content and activities, and employing an interaction design that is appropriate to the child's cognitive and psychomotor development (Crescenzi-Lanna and Grané-Oró, 2016). According to Educational App Store (EAS) – an independent app marketplace – the following guidelines are found in developmentally appropriate apps (Parmar, 2012):

- The apps are purposeful and educational.
- The apps are interactive, transparent and intuitive.
- The apps encourage the child to be in control.
- The apps encourage collaboration between the teacher/facilitator/parent and child.

- The apps can strengthen home and school connections.

- The apps must not contain any indication of violence or stereotyping.

The great majority of teachers and parents cannot clearly define what constitutes a developmentally appropriate application (Parmar, 2012). There exist whole categories of very good apps that are fun to play with but that have no real educational goals (Hirsh-Pasek et al., 2015). As Goodwin (2013) states, it is important for parents and educators to note that just because an app is in the 'Education' section of the digital stores, that does not necessarily mean it is educational. Additionally, there is simply not the time, money, or resources available to evaluate each app as it enters the market (Hirsh-Pasek et al., 2015). Cohen et al. (2011, p.9) state that research findings indicate that except for the lack of real educational goals there are several barriers that inhibit use and learning with 'educational' apps. These include:

- Apps' unclear, unfriendly or unresponsive user interface.

- App gameplay that lacks reward or feedback.

- Apps' obscure objectives.

- Too many distractions.

- Apps that lack 'palm rest', where buttons trigger themselves if accidentally touched within play area.

6.1 The difficulties that parents and educators are faced while selecting educational apps

With more than 80% of educational mobile applications in the digital stores of iTunes and Google Play appealing to children, parents and educators are faced with a multitude of decisions regarding their choice of the right app. The educational value and appropriateness of the app content can be difficult to determine (Yusop and Razak, 2013). As the App Store features over 80,000 education apps (Apple, 2016a), Rodríguez-Arancón et al. (2013) state that it would be difficult to conclude that all of the apps have been designed according to current theoretical understanding about effective pedagogical practices (Walsh et al., 2010) so as to be beneficial for learners of any age – and especially young children. As already mentioned, in 18 September 2013, the Apple company announced the addition of a 'Kids Category' to the App Store enabling software companies to target specific groups of customers (5 years and under, 6–8 years and 9–11 years). The creation of this new market category has given app developers a direct and relatively unregulated communication channel to a childhood audience. At the same time, Apple provides little information or guidance regarding the appropriate design and content guidelines for the apps targeting these age categories (Chau, 2014). Apps content undergo minimum custody. The criteria for the apps in this 'Kids category' do not include pedagogical criteria rather focused on apps' compliance with certain legal requirements, such as children's online privacy protection, no behavioural advertising and the prohibition in implementing financial transactions (Zytnik, 2014; Apple, 2016b). Moreover, as Ly (2015) points out, as more apps get uploaded to the digital stores, the competition between the developers becomes more fierce. Although, Vaala et al. (2015) suggest parents and educators try looking for information about apps of interest across

app stores and expert review sites or at producers' websites, this kind or research is not enough or reliable. The reason is that little information on the quality of apps is available, beyond the star ratings published on retailers' web pages or digital stores (Stoyanov et al., 2015), reviewer comments, or the inclusion of the app on a list (Bouck et al., 2016). Parents and educators do not know how the algorithms work for each of the app stores though some app marketing firms speculate that factors like the number of downloads, ratings, and engagement may be taken into account. Additionally, that competition has led many publishers to look outside of Apple and Google's ecosystem when the time comes to promote their creations to a wider audience. For example, they use Facebook, with the social network reporting its mobile ad business jumping from nothing only a few years ago, to 59% of its ad revenue (Perez, 2014).

Given the preponderance of apps available in the digital stores, teachers and parents need to make critical and informed decisions when selecting apps. Specifically, parents need evidence-based information about the safe and effective use of mobile devices, where to seek quality apps, and suggestions of ways these devices can be used at home to support learning (Goodwin, 2012). Yelland and Gilbert (2011) found in research that the majority of apps are classified as being 'drill and practice' and characterised by limited choice and specifically controlled outcomes. As a result, they suggest that educators and parents should take the time to play and become familiar with apps to ensure that they suit their goals for learning with the particular age range of their children. The reason is that '*claims of the developers are often overinflated and the scope of the app very limited and did not fully use the dynamic features and full potential of the tablet*' (Yelland and Gilbert, 2011, p.19). Henderson and Yeow (2012) point out that the choice of developmentally appropriate applications can be quite a difficult process for those interested. Often parents participate in mobile media activities with their children only if they find the activities enjoyable without worrying about the content of the apps (Heider and Jalongo, 2014). On the other hand, there is a multitude of 'edutainment' apps in the iTunes App Store, which are often like 'digital worksheet' or 'skill-and-drill' apps. Many of the apps in the market have interactive yet repetitive game formats with 'closed' content, that is the content could not be changed or extended by the user (Flewitt et al., 2014). Such apps rely on low levels of thinking skills and often do little more than promote rote learning, a memorisation of technique based on repetition (Grose, 2013), such as apps to rote learn colours, numbers, shapes or letters (Goodwin, 2013). For example, drill and practice may foster rote learning of facts, but it is not likely to promote deeper conceptual understanding (Hirsh-Pasek et al., 2015). Additionally, most educational apps that can be found on various websites like Eduapps or eduTecher are very simple apps without a defined goal that can be applied to formal education (Cardenal and López, 2015).

6.2 *The necessity for the introduction of new standards and assessments tools for the evaluation of the educational value of apps*

The popularity of mobile devices and their accompanying apps, as a new educational technology which shapes the way children learn, inevitably creates the need for the introduction of new standards and an evaluation system for the educational value of mobile apps, especially those that target young children (Brown et al., 2010). In a recent research study, Falloon (2013) studied interface design and content of selected apps for primary school children and younger and discussed the imperative need for both

researchers and software developers to work together so as to increase the educational value of applications addressed to young children. In a similar result, Kucirkova et al. (2014) emphasised the need for educational researchers, educators and software companies to find a common framework for consultation, given the growing demand for teachers to integrate mobile technologies and apps into their teaching, in order to assist 21st-century students in meaningful and real-world learning.

However, despite the popularity of mobile devices, there are relatively few public sources available for everyone associated with the development and use of educational apps for children. In fact, parents and educators have limited education themselves and/or limited evaluation tools to assess the potential benefits of those apps on children's learning and development (Emeeyou, 2012; Goodwin and Highfield, 2012). Software developers, parents and educators do not have a comprehensive guide to creating or evaluating mobile educational applications at their disposal. There are, on the internet, mainly scattered and often difficult to find fragmentary suggestions relating the educational appropriateness of an app. Especially for parents it is not enough to focus on an amount of time children are interacting with digital media. Shuler (2009b) advises parents and educators who are not sure which app is appropriate for their children and/or students to use the rule of 'Three C's'. The rule of 'Three C's' which was introduced by the early education researcher Lisa Guernsey for the evaluation of digital media for children is a method for checking the appropriateness of an app and is based on three different criteria:

- Content: if the application is age appropriate and if the learning object which it deals with is developmentally appropriate.

- Context: if the application interacts with the child and if the child learns through play.

- Child: what stimuli a child could acquire from this application.

Respectively, according to the non-profit educational organisation 'Tablets for Schools' the surest way for teachers and parents to select developmentally appropriate apps is to browse websites specialised in educational applications, such as the EAS (http://www. educationalappstore.com) (Tablets for Schools, 2014). The EAS is an independent app marketplace in which visitors can find reliable information, as well as applications that have been evaluated by other teachers and are organised by topic, age and curriculum relevance. This organisation advises parents and educators to look for applications, which meet the academic standards, and not choose applications according to their popularity in the digital stores. For example, an app in Google's digital store is considered popular among users when it has many ratings according to Google Play's 5-star rating system or the number of cumulative app downloads is big enough.

7 Assessment challenges in the usefulness of educational apps for children

The creation of educational software for preschool and primary school children has long preoccupied many within the education research community, since the introduction of personal computers in classrooms by the early 1980s. Falloon (2013) states that researchers attempting to measure the effectiveness and educational value of mobile applications face the same challenges as those who tried to measure the educational

impact of the computer software. The use of design principles applied to the elements of educational software for personal computers can be generally used in the design of educational apps.

However, with the new interactive technologies, the criteria for assessing the quality of mobile products targeting children as young as 2 years old must be continually updated to reflect recent trends in handling behaviour and content of self-proclaimed educational apps (Shoukry et al., 2012). McKnight and Fitton (2010) refer to usability issues that emerge in numerous aspects of interactive activities with apps, such as a lack of haptic feedback, which is associated with the use of 'soft buttons' (or 'virtual buttons'), as well as interaction style changes with which children should familiarise themselves. Similarly, Brown et al. (2010) point out that design approaches, though widely used for decades, are based on traditional interaction technologies and methods such as the use of mouse or keyboards as input devices require a complete overhaul due to the use of touchscreens and gesture-based interaction technologies. Only, a small number of developers at both small start-ups and bigger toy/media companies have used research-based approaches with preliminary results of research (Hirsh-Pasek et al., 2015).

7.1   The problems of evaluating educational apps

In general, obtaining the assessment of apps becomes an extremely difficult problem due to the huge number of self-proclaimed educational apps in Apple and Google digital stores (Levine, 2012). An obstacle in finding developmentally appropriate apps targeted at children, according to McKnight and Cassidy (2010), is the fact that even though children are considered a special user group, mobile device design guidelines formed from research based on adult participants may not transfer all that well to children (Lumsden, 2012). Software design principles that are intended for mature audiences cannot successfully be transferred to children's educational software (McKnight and Cassidy, 2010). Crescenzi-Lanna and Grané-Oró (2016), in a design analysis of 100 applications considered by educators and parents as potentially educational resources in 2014, found clear issues related to visual and interaction design, adaptability, layout and navigation, making it evident that there is a lack of quality and adaptation in terms of child development. A characteristic example is the use of textual messages that often accompany key information, instructions, and feedback in apps for preschoolers. Design for children is a unique realm of study as is design for older users (Stephanidis, 2009), and, as such, may interact with technologies in different ways to other users (Lumsden, 2012). Educational software addressed to ECE has certain characteristics compared to programs designed for use in general school education classrooms or to general-purpose software. This kind of software is based primarily on the use of graphics, video, animation effects, and sounds as well as the absence or minimum presence of texts (Nikiforidou and Pange, 2010).

Additionally, according to Haugland (1999), educational software for preschoolers and kindergarten kids should give priority to the process rather than the product, providing opportunities and intrinsically motivate children to be more involved in their own learning (Carlton and Winsler, 1998). Although apps are available for preschoolers to build communication skills, pre-literacy skills, pre-math skills, as well as science skills (Heider and Jalongo, 2014), in fact, there are few examples of well-designed educational applications to get the kids learning, creating and playing (Michael Cohen Group LLC, 2011). It is common that text-heavy interfaces are included even in apps for preschoolers,

with the assumptions that parents will read the content to their children (Heider and Jalongo, 2014). Since 2010, Walker, realising the widespread adoption of mobile devices, and associated challenges of a vast array of apps, wondered what aspects are involved in making an app developmentally appropriate (Walker, 2010), concluding that there is not a single feature but a number of features, which vary and are evaluated differently by a parent, a teacher and a software developer (Walker, 2010). For example, he states that a website targeted at software developers places greater emphasis on the technical features of an app such as the platform's reliability and compatibility, putting less emphasis on other characteristics such as the Graphical User Interface (GUI) of the app. However, when assessing the usefulness of educational apps, these criteria represent the minimum, as the focus should be on the educational benefits of the app (Walker, 2010). Another website set priority to the GUI and the applications' adaptation to the user's needs. Walker considered the criteria related to the GUI and the application adaptability significant (Walker, 2010). The American non-profit organisation Sesame Workshop, formerly known as the Children's Television Workshop, states that it can be beneficial to children of preschool age, to get involved with apps which support learner's cognitive needs and development (scaffolding) (Sesame Workshop, 2012). Furthermore, independent organisations such as Common Sense Media, Kindertown, Yogi Play, Children's Technology Review, Parents' Choice and Appolicious have started describing highly effective learning apps' desirable characteristics (Guernsey et al., 2012). With reference to the above-mentioned subject, it is clearly understood that there is either no criteria or criterion to characterise a self-proclaimed educational application as developmentally appropriate or not. International websites that use a solid methodology in terms of quality while reviewing children's apps are the Mind Shift, Children's technology review, Common Sense Media, technology in education, and best apps for kids (Crescenzi-Lanna and Grané-Oró, 2016). Additionally, Lisa Guernsey and Michael Levine, co-authors of the book entitled *Tap, Click, Read: Growing Readers in a World of Screens*, suggested a series of curation sites for parents and educators which review educational apps. Those sites are Balefire Labs (balefirelabs.com), Children's Technology Review (childrenstech.com), Common Sense Media (commonsensemedia. org), Digital Storytime (digital-storytime.com), Graphite (graphite.org), Know What's Inside (knowwhatsinside.com), Parent's Choice Foundation (parents-choice.org), and Teachers with Apps (teacherswithapps.com) (Guernsey and Levine, 2015). Sesame Street, the non-profit organisation behind children's television programming with the landmark Sesame Street, published recently a checklist, which offers key findings from touchscreen studies and tips for designing and developing apps and e-books for preschoolers (Sesame Workshop, 2012). Although the paper is addressed mostly to evaluators and software developers, it could be also a useful guide both for parents and educators.

8 Conclusion

The 21st century is an age of mobility and ease (Ellingson, 2016). Young children are being increasingly exposed to media, technology, and screen time (MeTS) at home and in instructional settings (Sharkins et al., 2015). The use of smart mobile devices among primary school children and toddlers is also growing exponentially as children have more access to smartphones through their parents (increasing mobile penetration globally) and

as schools embrace technology (Zytnik, 2014). The ease of use, portability, speed and responsiveness of the smart mobile devices and especially tablets were said to make it an ideal learning tool (Watts et al., 2012). Although some educators argue that they have no place in young children's lives the majority enthusiastically embrace those new media for learning (Flewitt et al., 2014). The reason is that 'active, appropriate use of technology and media can support and extend traditional materials in valuable ways … both cognitive and social' (NAEYC, 2012, p.7). The amount of time that children spend with digital media and the surge in educational apps' popularity suggest that at least some apps are being used in an attempt to supplement learning outside of school (Hirsh-Pasek et al., 2015).

At the same time, this new technology is not a panacea. As the Office of Educational Technology advise, 'we have to be cognizant of a new digital divide – the disparity between students who use technology to create, design, build, explore, and collaborate and those who simply use technology to consume media passively' (Office of Educational Technology, 2016, p.18). Although tablets themselves are highly versatile and user-friendly for children, they must be coupled with equally well-designed software. According to the NAEYC, in a 1996 position statement point out that: 'Choosing appropriate software is similar to choosing appropriate books for the classroom' (NAEYC, 1996). Smart mobile devices and especially tablets are a technological tool which, when combined with applications that have the appropriate content and design, is able to support the cognitive development of young children. Touchscreen tablets offer many features that enable emergent literacy development as children are able to interact with a range of single and multitouch gestures (Ellingson, 2016). Thus, 'educational' apps are largely unregulated and untested (Hirsh-Pasek et al., 2015). Only when this is achieved, may tablets offer children a mechanism to articulate their creative process from their own perspective (Arnott et al., 2016).

Incorporating touchscreen technology in the repertoire of young children's everyday literacy experiences offers new opportunities for ECE (Flewitt et al., 2014). Apps present a significant opportunity for out-of-school, informal learning when designed in educationally appropriate ways (Hirsh-Pasek et al., 2015). However, researchers point out both teachers and parents face difficulties in evaluating self-proclaimed educational apps. In today's technologically saturated society, parents and teachers are both challenged and obligated to ensure that their children's interactions with touchscreen technologies are developmentally appropriate, interactive, and beneficial (Sharkins et al., 2015). Despite the fact that the market is saturated with applications for children, the label 'educational' or 'for children' does not indicate that an app has been validated and tested (Guernsey, 2013, as cited in Crescenzi-Lanna and Grané-Oró, 2016).

We live in the first wave of app development, when apps are often just migrations of games and learning scenarios that already exist in non-digital form (Hirsh-Pasek et al., 2015). On the one hand, they face an increasing number of educational apps that become available daily. On the other hand, the majority of the apps have failed to keep their promises to support learning in a purposeful, effective, and enjoyable way. Additionally, in the educational category on Apple's and Google's app store there is often intruding, 'parasitic' content that calls itself as educational in order to exploit the popularity of this category to reap financial benefits. App developers need to consider the design and production of content creation in constructive apps, in order to capitalise on the unique functionality and capabilities of the tablets (Goodwin, 2012). We have to move, in the second wave of educational apps, to apps that foster digital experiences that are

cognitively active, deeply engaging, meaningful, and socially interactive within the context of a learning goal, rather than simply mimicking and extending older media like books, worksheets, television, or even video games (Hirsh-Pasek et al., 2015). We have to keep in mind that, although the selection of good app for children is important, previous studies have shown that their learning performances could be disappointing without proper guidance or learning design (Hwang et al., 2015). For this to happen, it is necessary to create an updated comprehensive guide and/or framework to provide researchers, designers, practitioners, evaluators, educators and parents with the necessary tools in order to progressively refine their practice with children's apps and to enrich traditional design-based research with novel affordances of 21st-century technologies (Kucirkova, 2016). 'Mobile devices are an integral part of children's lives and they are here to stay' (Shuler, 2009b).

References

Abdul Aziz, N.A.B., Batmaz, F., Stone, R. and Chung, P.W.H. (2013) 'Selection of touch gestures for children's applications', *Proceedings of the Science and Information Conference* (SAI), 7–9 October, London, pp.721–726.

Apple (2015) *App Store Rings in 2015 with New Records*. Available online at: https://www.apple.com/pr/library/2015/01/08App-Store-Rings-in-2015-with-New-Records.html (accessed on 16 July 2016).

Apple (2016a) *IPad in Education*. Available online at: http://www.apple.com/education/apps-books-and-more/ (accessed on 12 June 2016).

Apple (2016b) *App Store Review Guidelines*. Available online at: https://developer.apple.com/app-store/review/guidelines/#kids-category (accessed on 18 June 2016).

Arnott, L., Grogan, D. and Duncan, P. (2016) 'Lessons from using iPads to understand young children's creativity', *Contemporary Issues in Early Childhood*, Vol. 17, No. 2, pp.157–173.

Avtar, T. (2014) *How App Markets are Adding a Lot of Value in Education, Think Tab Blogs*. Available online at: http://www.thinktab.com/how-app-markets-are-adding-a-lot-of-value-in-education/ (accessed on 2 July 2016).

Bayles, J. and Knoke-Staggs, G. (2013) 'Tablets and children: intuitive technology and new literacies', *Tennessee Libraries*, Vol. 63, No. 2, p.1.

Beeland, W.D.J. (2002) *Student Engagement, Visual Learning and Technology: Can Interactive Whiteboards Help?* Available online at: http://chiron.valdosta.edu/are/Artmanscrpt/vol1no1/beeland_am.pdf (accessed on 13 June 2016).

Bennett, K.R. (2011) 'Less than a class set', *Learning and Leading with Technology*, Vol. 39, No. 4, pp.22–25.

Beschorner, B. and Hutchison, A. (2013) 'iPads as a literacy teaching tool in early childhood', *International Journal of Education in Mathematics, Science and Technology*, Vol. 1, No. 1, pp.16–24.

Bouck, E.C., Satsangi, R. and Flanagan, S. (2016) 'Focus on inclusive education: evaluating apps for students with disabilities: supporting academic access and success', *Childhood Education*, Vol. 92, No. 4, pp.324–328.

Brown, Q., Bonsignore, E., Hatley, L., Druin, A., Walsh, G., Foss, E. and Brewer, R. (2010) 'Clear panels: a technique to design mobile application interactivity', *Proceedings of DIS '10*, ACM, New York, pp.360–363.

Campaign for a Commercial-Free Childhood, Alliance for Childhood and Teachers Resisting Unhealthy Children's Entertainment (2012) *Facing the Screen Dilemma: Young Children, Technology and Early Education*, Campaign for a Commercial-Free Childhood, Boston, MA/Alliance for Childhood, New York, NY.

Cardenal, F.J. and López, V.F. (2015) 'Education apps – one step beyond: it's time for something more in the education apps world', *International Joint Conference*, Vol. 369, pp.571–581.

Carlton, M.P. and Winsler, A. (1998) 'Fostering intrinsic motivation in early childhood classrooms', *Early Childhood Education Journal*, Vol. 25, No. 3, pp.159–166.

Chau, C.L. (2014) *Positive Technological Development for Young Children in the Context of Children's Mobile Apps*, Doctoral Dissertation, Tufts University, USA.

Chen, C.H., Hwang, G.J. and Tsai, C.H. (2014) 'A progressive prompting approach to conducting context-aware learning activities for natural science courses', *Interacting with Computers*, Vol. 26, No. 4, pp.348–359.

Chiong, C. and Shuler, C. (2010) *Learning: Is There an App for That? Investigations of Young Children's Usage and Learning with Mobile Devices and Apps*, The Joan Ganz Cooney Center at Sesame Workshop, New York.

Cohen, M., Hadley, M. and Frank, M. (2011) *Young Children, Apps & iPad*, Michael Cohen Group, New York.

Common Sense Media (2013) *Zero to Eight: Children's Media Use in America 2013*, Common Sense Media, San Francisco, CA.

Coughlan, S. (2014) *Tablet Computers in 70% of Schools*. Available online at: http://www.bbc.com/ news/education-30216408 (accessed on 16 July 2016).

Crescenzi-Lanna, L. and Grané-Oró, M. (2016) 'An analysis of the interaction design of the best educational apps for children aged zero to eight', *Comunicar*, Vol. 24, No. 46, pp.77–85.

Crook, C. (1992) 'Young children's skill in using a mouse to control a graphical computer interface', *Computers & Education*, Vol. 19, No. 3, pp.199–207.

Dogtiev, A. (2015) *App Revenue Statistics 2015*. Available online at: http://www.businessofapps.com/app-revenue-statistics/ (accessed on 5 July 2016).

Donahoo, D. (2012) *The Changing Nature of App Design and Development for Kids*. Available online at: http://www.wired.com/2012/01/kids-app-design/ (accessed on 5 July 2016).

Ebbeck, M., Yim, H.Y.B., Chan, Y. and Goh, M. (2016) 'Singaporean parents' views of their young children's access and use of technological devices', *Early Childhood Education Journal*, Vol. 44, No. 2, pp.127–134.

Ellingson, K. (2016) *Interactive Technology Use in Early Childhood Programs to Enhance Literacy Development & Early Literacy Development for Children with Cochlear Implants*, Culminating Projects in Child and Family Studies, Paper 3. Available online at: http:// repository.stcloudstate.edu/cfs_etds/3

Emeeyou (2012) *Should Parents Expect More? Making the Case for Evidence-Based Early Childhood Education Mobile Applications*. Available online at: http://www.emeeyou.com/wp-content/uploads/2012/11/emeeyou_white_paper_04112012.pdf (accessed on 4 July 2016).

Epstein, A.S. (2015) *Using Technology Appropriately in the Preschool Classroom*, HighScope Extensions, Vol. 28, No. 1, pp.1–11.

Falloon, G. (2013) 'Young students using iPads: app design and content influences on their learning pathways', *Computers & Education*, Vol. 68, pp.505–521.

Flewitt, R., Messer, D. and Kucirkova, N. (2014) 'New directions for early literacy in a digital age: the iPad', *Journal of Early Childhood Literacy*, Vol. 15, No. 3, pp.289–310.

Geist, E.A. (2012) 'A qualitative examination of two-year-olds interaction with tablet based interactive technology', *Journal of Instructional Psychology*, Vol. 39, No. 1, pp.26–35.

Goodwin, K. (2012) *Use of Tablet Technology in the Classroom*, NSW Curriculum and Learning Innovation Centre. Available online at: http://www.tale.edu.au/ (accessed on 14 July 2016).

Goodwin, K. (2013) *iPads & Young Children: An Essential Guide for Parents*. Available online at: http://goo.gl/ZYPiaa (accessed on 14 June 2016).

Goodwin, K. and Highfield, K. (2012) 'iTouch and iLearn: an examination of "educational" apps', Paper presented at the *Early Education and Technology for Children Conference*, 14–16 March, Salt Lake City, Utah.

Grose, M. (2013) *The Good and the Bad of Digital Technology for Kids*. Available online at: http://www.lawley.wa.edu.au/upload/pages/parenting-resources-insight/insights_learning_ technology.pdf?1445403034 (accessed on 14 July 2016).

Guernsey, L. and Levine, M.H. (2015) *How to Find Apps for Literacy Learning*. Available online at: http://www.tapclickread.org/wp-content/uploads/2016/05/2016.06.03_NA_TCR_ FindApps.pdf (accessed on 20 May 2016).

Guernsey, L., Levine, M., Chiong, C. and Severns, M. (2012) *Pioneering Literacy: In the Digital Wild West: Empowering Parents and Educators*. Available online at: http://gradelevelreading. net/wp-content/uploads/2012/12/GLR_TechnologyGuide_final.pdf (accessed on 22 May 2016).

Haugland, S.W. (1999) *Developmental Software Scale*, K.I.D.S. & Computers, Inc., Cape Girardeau, MO.

Heider, K.L. and Jalongo, M.R. (Eds) (2014) *Young Children and Families in the Information Age: Applications of Technology in Early Childhood*, Vol. 10, Springer, Dordrecht, The Netherlands.

Henderson, S. and Yeow, J. (2012) 'iPad in education: a case study of iPad adoption and use in a primary school', *45th Hawaii International Conference, System Science (HICSS)*, 4–7 January, IEEE Computer Society, Washington, DC, pp.78–87.

Highfield, K. and Goodwin, K. (2013) 'Apps for mathematics learning: a review of "educational" apps from the iTunes app store', in Steinle, V., Ball, L. and Bardini, C. (Eds): *Mathematics Education: Yesterday, Today and Tomorrow (Proceedings of the 36th annual conference of the Mathematics Education Research Group of Australasia)*, MERGA, Melbourne, VIC.

Hiniker, A., Sobel, K., Hong, S.R., Suh, H., Kim, D. and Kientz, J.A. (2015) 'Touchscreen prompts for preschoolers: designing developmentally appropriate techniques for teaching young children to perform gestures', *Proceedings of the 14th International Conference on Interaction Design and Children*, ACM, New York, pp.109–118.

Hirsh-Pasek, K., Zosh, J.M., Golinkoff, R.M., Gray, J.H., Robb, M.B. and Kaufman, J. (2015) 'Putting education in "educational" apps lessons from the science of learning', *Psychological Science in the Public Interest*, Vol. 16, No. 1, pp.3–34.

Hourcade, J.P., Bederson, B.B. and Druin, A. (2004) 'Preschool children's use of mouse buttons', *CHI '04 Extended Abstracts on Human Factors in Computing Systems*, ACM, New York, NY, pp.1411–1412.

Hung, C.M., Hwang, G.J. and Wang, S.Y. (2014a) 'Effects of an integrated mind-mapping and problem-posing approach on students' in-field mobile learning performance in a natural science course', *International Journal of Mobile Learning and Organisation*, Vol. 8, No. 3, pp.187–200.

Hung, P.H., Hwang, G.J., Lee, Y.H., Wu, T.H., Vogel, B., Milrad, M. and Johansson, E. (2014b) 'A problem-based ubiquitous learning approach to improving the questioning abilities of elementary school students', *Education Technology & Society*, Vol. 17, No. 4, pp.316–334.

Hwang, G.J., Wang, S.Y. and Lai, C.L. (2015) 'Seamless flipped learning – a mobile technology-enhanced flipped classroom with effective learning strategies', *Journal of Computers in Education*, Vol. 2, No. 4, pp.449–473.

Kucirkova, N. (2016) 'iRPD – a framework for guiding design-based research for iPad apps', *British Journal of Educational Technology*, Vol. 48, No. 2, pp.598–610, doi:10.1111/ bjet.12389.

Kucirkova, N., Messer, D., Sheehy, K. and Fernández Panadero, C. (2014) 'Children's engagement with educational iPad apps: insights from a Spanish classroom', *Computers & Education*, Vol. 71, pp.175–184.

Levine, M.J. (2012) *Reading with Young Children: Something Old and Something New*?, Joan Ganz Cooney Center, New York.

Lumsden, J. (Ed.) (2012) *Social and Organizational Impacts of Emerging Mobile Devices: Evaluating Use*, IGI Global, Hershey, PA.

Ly, A. (2015) *Standing Out in the App Crowd*. Available online at: http://www. joanganzcooneycenter.org/2015/12/17/standing-out-in-the-app-crowd/ (accessed on 19 July 2016).

Lynch, J. and Redpath, T. (2014) '"Smart" technologies in early years' literacy education: a metanarrative of paradigmatic tensions in iPad use in an Australian preparatory classroom', *Journal of Early Childhood Literacy*, Vol. 14, No. 2, pp.147–174.

Madden, M., Lenhart, A., Duggan, M., Cortesi, S. and Gasser, U. (2013) *Teens and Technology 2013*, Pew Internet & American Life Project, Washington, DC.

McKnight, L. and Cassidy, B. (2010) 'Children's interaction with mobile touch-screen devices: experiences and guidelines for design', *International Journal of Mobile Human Computer Interaction*, Vol. 2, No. 2, pp.1–18.

McKnight, L. and Fitton, D. (2010) 'Touch-screen technology for children: giving the right instructions and getting the right responses', *Proceedings of the 9th International Conference on Interaction Design and Children (IDC '10)*, ACM, New York, pp.238–241.

Michael Cohen Group LLC (2011) *Young Children, Apps and iPad (Research Undertaken as Part of the Evaluation Activities of the US Department of Education Ready to Learn Program)*. Available online at: http://www.mcgrc.com/wp-content/uploads/2011/07/iPad-study-cover-page-report-mcginfo_new-online.pdf (accessed on 10 July 2016).

Mohapatra, M. and Hasty, A. (2012) *Mobile Apps for Kids: Disclosures Still Not Making the Grade. Washington: Federal Trade Commission*. Available online at: http://www. ftc.gov/opa/2012/12/kidsapp.shtm (accessed on 12 July 2016).

Muller, M.J. (2002) 'Participatory design: the third space in HCI', in Jacko, J.A. and Sears, A. (Eds): *The Human-Computer Interaction Handbook*, L. Erlbaum Associates Inc., Hillsdale, NJ, pp.1051–1068.

NAEYC (National Association for the Education of Young Children) (1996) *Technology and Young Children – Ages 3 through 8: A Position Statement of the National Association for the Education of Young Children*, Washington, DC. Available online at: http://www. naeyc.org/about/positions/pdf/PSTECH98.pdf (accessed on 12 July 2016).

NAEYC (2012) *Technology and Interactive Media as Tools in Early Childhood Programs Serving Children from Birth through Age 8: Spotlight on Young Children and Technology*, National Association for the Education of Young Children and the Fred Rogers Center for Early Learning and Children's Media, Washington, DC, pp.61–70.

Nielsen (2012) *American Families See Tablets as Playmate, Teacher and Babysitter*. Available online at: http://www.nielsen.com/us/en/insights/news/2012/american-families-see-tablets-as-playmateteacher-and-babysitter.html (accessed on 10 July 2016).

Nikiforidou, Z. and Pange, J. (2010) 'Teachers' evaluation of preschool educational software: the case of probabilistic thinking', *Procedia – Social and Behavioral Sciences*, Vol. 9, pp.537–541.

Office of Educational Technology (2016) *2016 National Education Technology Plan (NETP)*, Department of Education. Available online at: http://tech.ed.gov (accessed on 27 June 2016).

Olney, I., Herrington, J. and Verenikina, I. (2008) 'iPods in early childhood: mobile technologies and story telling', *Hello! Where Are You in the Landscape of Educational Technology? Proceedings Ascilite Melbourne 2008*, ASCILITE, Melbourne, pp.419–427.

Orfanakis V. and Papadakis, S. (2014) 'A new programming environment for teaching programming. A first acquaintance with Enchanting', *The 2nd international virtual Scientific Conference - Scieconf 2014*, EDIS - University of Zilina, Slovakia, pp.268–273.

Papadakis, S. (2016) 'Creativity and innovation in European education: 10 years eTwinning. Past, present and the future', *International Journal of Technology Enhanced Learning*, Vol. 8, Nos. 3/4, pp.279–296.

Papadakis, S. and Kalogiannakis, M. (2010) 'eTwinning in the early childhood as starting line of innovative practices for the didactic of natural sciences', Paper presented at the *HSci2010 7th International Conference Hands-on Science Bridging the Science and Society gap*, 25–31 July, University of Crete, Rethymno, Greece.

Papadakis, S. and Orfanakis, V. (2014) 'A new programming environment for teaching programming: a first acquaintance with enchanting', Paper presented at the *2nd international virtual Scientific Conference – Scieconf*, EDIS – Publishing Institution of the University of Zilina, Zilina, pp.268-273.

Papadakis, S., Kalogiannakis, M., Orfanakis, V. and Zaranis, N. (2014) 'Novice Programming Environments. Scratch & App Inventor: a first comparison', in Fardoun, H.M. and Gallud, J.A. (Eds): *Proceedings of the 2014 Workshop on Interaction Design in Educational Environments*, ACM, New York, pp.1–7.

Papadakis, S., Kalogiannakis, M. and Zaranis, N. (2016a) 'Developing fundamental programming concepts and computational thinking with ScratchJr in preschool education: a case study', *International Journal of Mobile Learning and Organisation*, Vol. 10, No. 3, pp.187–202.

Papadakis, S., Kalogiannakis, M. and Zaranis, N. (2016b) 'Improving mathematics teaching in kindergarten with realistic mathematical education', *Early Childhood Education Journal*, doi:10.1007/s10643-015-0768-4.

Papadakis, S., Kalogiannakis, M. and Zaranis, N. (2016c) 'Comparing tablets and PCs in teaching mathematics: an attempt to improve mathematics competence in early childhood education', *Preschool and Primary Education*, Vol. 4, doi:10.12681/ppej.8779.

Papadakis, S., Kalogiannakis, M. and Zaranis, N. (2017) 'Designing and creating an educational app rubric for preschool teachers', *Education and Information Technologies*, pp.1–19.

Papadakis, S., Kalogiannakis, M., Orfanakis, V. and Zaranis, N. (2016) 'Using scratch and app inventor for teaching introductory programming in secondary education. A case study', *International Journal of Technology Enhanced Learning*, Vol. 8, Nos. 3/4, pp.217–233.

Parmar, N. (2012) *Assessing the Quality of Apps for Usage with Young Children*. Available online at: http://www.educationalappstore.com/blog/assessing-the-quality-of-apps-for-usage-with-young-children/ (accessed on 27 June 2016).

Pearsall, D.A. (2014) *Young Children's Preferences for Musical IPad Apps*, Doctoral Dissertation, University of Delaware.

Perez, S. (2014) *iTunes App Store Now Has 1.2 Million Apps, Has Seen 75 Billion Downloads to Date*. Available online at: http://techcrunch.com/2014/06/02/itunes-app-store-now-has-1-2-million-apps-has-seen-75-billion-downloads-to-date/ (accessed on 15 June 2016).

Plowman, L. (2012) *Press for Play: Using Technology to Enhance Learning in the Early Years*, ESRC Technology Enhanced Learning Research Programme, London.

Rideout, V. (2011) *Zero to Eight: Children's Media Use in America*, Common Sense Media, San Francisco, CA. Available online at: http://www.commonsensemedia.org/sites/default/files/research/ zerotoeightfinal2011.pdf (accessed on 12 July 2016).

Robijt, S. and Van den Broeck, W. (2013) 'Children and tablets: towards an interactive television experience?', *Proceedings of the 11th European Conference on Interactive TV*, 24–26 June, Como, Italy.

Rodríguez-Arancón, P., Arús, J. and Calle, C. (2013) 'The use of current mobile learning applications in EFL', *Procedia – Social and Behavioral Sciences*, Vol. 103, pp.1189–1196.

Satish, M. (2015) *Forrester Research World Mobile Application Spending Forecast, 2015 to 2020 (Global)*. Available online at: https://www.forrester.com/report/Forrester+Research+World+Mobile+ Application+ Spending+Forecast+2015+To+2020+Global/-/E-RES122413 (accessed on 24 June 2016).

Sesame Workshop (2012) *Best Practices: Designing Touch Tablet Experiences for Preschoolers*. Available online at: http://www.sesameworkshop.org/wp_install/wp-content/uploads/2013/04/Best-Practices-Document-11-26-12.pdf (accessed on 15 June 2016).

Sharkins, K.A., Newton, A.B., Albaiz, N.E.A. and Ernest, J.M. (2015) 'Preschool children's exposure to media, technology, and screen time: perspectives of caregivers from three early childcare settings', *Early Childhood Education Journal*, Vol. 44, No. 5, pp.437–444.

Shoukry, L.A., Sturm, C. and Galal-Edeen, G. (2012) 'Pre-MEGa: a proposed framework for the design and evaluation of preschoolers' mobile educational games', *The Proceedings of The International Conference on Engineering Education, Instructional Technology, Assessment, and E-learning (EIAE 12)*, Vol. 313, pp.385–390.

Shuler, C. (2009a) *iLearn: A Content Analysis of the iTunes App Store's Education Section*, The Joan Ganz Cooney Center at Sesame Workshop, New York.

Shuler, C. (2009b) *Pockets of Potential: Using Mobile Technologies to Promote Children's Learning*, The Joan Ganz Cooney Center at Sesame Workshop, New York.

Shuler, C. (2012) *iLearn II: An Analysis of the Education Category of Apple's App Store*, The Joan Ganz Cooney Center at Sesame Workshop, New York.

Statista (2016a) *Number of Available Apps in the Apple App Store from July 2008 to June 2015*. Available online at: http://www.statista.com/statistics/263795/number-of-available-apps-in-the-apple-app-store/ (accessed on 24 June 2016).

Statista (2016b) *Number of Available Applications in the Google Play Store from December 2009 to February 2016*. Available online at: https://www.statista.com/statistics/266210/number-of-available-applications-in-the-google-play-store/ (accessed on 24 June 2016).

Stephanidis, C. (Ed.) (2009) *The Universal Access Handbook*, CRC Press, Hoboken, NJ.

Stoyanov, S., Hides, L., Kavanagh, D., Tjondronegoro, D., Zelenko, O. and Mani, M. (2015) 'Mobile app rating scale: a new tool for assessing the quality of health-related mobile apps', *JMIR mHealth and uHealth*, Vol. 3, No. 1, e27.

Tablets for Schools (2014) *How Do You Identify a Good Educational App? – By the Educational Appstore*. Available online at: http://goo.gl/MY5reg (accessed on 24 June 2016).

Techopedia (2016) *Mobile Application (Mobile App)*. Available online at: https://www.techopedia.com/definition/2953/mobile-application-mobile-app (accessed on 15 June 2016).

Trucano, M. (2015) *Tablets in Education*. Available online at: http://blogs.worldbank.org/edutech/tablets-education (accessed on 15 June 2016).

Vaala, S., Ly, A. and Levine, M.H. (2015) *Getting a Read on the App Stores*. Available online at: http://www.joanganzcooneycenter.org/wp-content/uploads/2015/12/jgcc_gettingaread.pdf (accessed on 17 July 2016).

Walker, H. (2010) 'Evaluating the effectiveness of apps for mobile devices', *Journal of Special Education Technology*, Vol. 26, No. 4, pp.59–63.

Walsh, G., Sproule, L., McGuinness, C., Trew, K. and Ingram, G. (2010) *Developmentally Appropriate Practice and Play-Based Pedagogy in Early Year's Education: A Literature Review of Research and Practice School of Psychology*, Queen's University Belfast Stranmillis University College, Belfast.

Waters, D. (2009) *The Future Beneath Your Fingertips*. Available online at: http://news.bbc.co.uk/2/hi/technology/7945680.stm (accessed on 15 June 2016).

Watts, L., Brennan, S. and Phelps, R. (2012) 'iPadiCan: trialling iPads to support primary and secondary students with disabilities', *Australian Educational Computing*, Vol. 27, No. 2, pp.4–12.

Wikipedia (2016) *Mobile App*. Available online at: https://en.wikipedia.org/wiki/Mobile_app (accessed on 15 June 2016).

Wood, E., Petkovski, M., De Pasquale, D., Gottardo, A., Evans, M.A. and Savage, R.S. (2016) 'Parent scaffolding of young children when engaged with mobile technology', *Frontiers in Psychology*, Vol. 7, p.690.

Yelland, N. and Gilbert, C. (2011) *iPlay, iLearn, iGrow*, IBM Paper, London.

Yusop, F.D. and Razak, R.A. (2013) 'Mobile educational apps for children: towards development of i-CARES framework', *Annual International Conference on Management and Technology in Knowledge, Service, Tourism & Hospitality*, Jakarta, Indonesia.

Zaranis, N. (2013) 'The use of information and communication technologies in the first grade of primary school for teaching rectangles based in realistic mathematics education', *2013 Fourth International Conference on Information, Intelligence, Systems and Applications (IISA)*, IEEE, Piraeus/Athens, Greece, pp.1–6.

Zaranis, N. (2016) 'The use of ICT in kindergarten for teaching addition based on realistic mathematics education', *Education and Information Technologies*, Vol. 21, No. 3, pp.589–606.

Zaranis, N., Kalogiannakis, M. and Papadakis, S. (2013) 'Using mobile devices for teaching realistic mathematics in kindergarten education', *Creative Education (Special Issue in Preschool Education)*, Vol. 4, No. 7A1, pp.1–10.

Zytnik, M. (2014) *School Report for Apple App Store and Google Play*. Available online at: https://www.adjust.com/company/overview/2014/09/29/kids-apps-report-apple-itunes-google-play/ (accessed on 15 June 2016).

Evaluating educational software for children with LD: What parents need to know. Although many software developers know it is important to consult with educational experts, much software still is developed without consideration of key educational factors that may have an impact on learning 1 . Here are some examples of what researchers have discovered on the topic So how do parents cope with the need to integrate computer-based learning materials into their child's learning tasks at home, while also recognizing the limitations of current software? You will want to consider the following important features when assessing a piece of educational software Educational apps are making things easier for children to understand. Books are often found to be tiring and boring for children while replacing them with colourful pages and moving animations can make learning fun to the core. Benefits of Using Mobile Applications in Education. 1. Enhanced Interaction. Most of the apps promote child-friendly control. Children should only need to reach out for the device when they feel like learning. Little ones can operate it without much effort. 7. Leisure Hours Utilization. While selecting apps for children, parents and teachers can contribute a lot. 14. Sustainability. Using mobile apps for learning is more sustainable compared to the traditional learning methods which include papers, pencils, and pens.