Abstract

The incorporation of digital technologies is explicitly addressed in the Early Years Learning Framework for Australia. The use of Augmented Reality (AR) technology, as one form of digital technology, is increasingly embedded in digital applications because it allows individuals to interact with real and virtual objects. A significant body of research has reported the benefits afforded by the use of AR technology in schools and higher education settings. However, little is known about the contribution of AR technology to teaching practice and child learning outcomes in the preschool years. Here, we present a summary of the limited research that has explored the use of AR in preschool curricula and argue for the need for further research to explore the contribution of AR to high-quality pedagogical practice.

Introduction

The contribution made by the considered incorporation of technologies in opportunities for play-based learning in the context of early childhood education is well established (Bird & Edwards, 2015; Department of Education, Employment and Workplace Reform, 2009; Edwards, Straker & Oakey, 2018). Indeed, digital technologies should form 'an integral part of the curriculum-in-practice' (Grieshaber & Yelland, 2005, p. 192). Bird and Edwards (2015) provided a valuable step up from the debate about the appropriateness of the inclusion of digital technology in play-based early childhood curricula by proposing a Digital Play Framework. This framework assists early childhood educators to observe children's playful engagement with digital technologies as the nature of their engagement moves through exploratory, problem-solving and skill acquisition, to symbolic play and innovative play. However, the pace with which technology is evolving and the frequency with which young children are observing and using digital technology is remarkable and digital technology is increasingly present in early learning settings. In this paper, we focus on Augmented Reality (AR) technology, a technology that is increasingly prevalent in home environments for many children, and propose the need for the impact of AR as a help or a hindrance in early childhood curricula to be trialled and evaluated.

AR technology is one form of digital technology that is becoming increasingly commonplace. It creates the perception that virtual objects are present in the real world – thus, reality is 'augmented' – creating a mixed reality that appears to coexist in space and time (Chen, Liu, Cheng & Huang, 2017). One example of AR technology that has received much media

attention is ‘Pokémon GO’, the first mainstream smartphone game to include AR (Deloittes, 2018). However, many smartphone apps now include AR, for example, by adding rabbit ears to human faces in video chat applications (apps), or hearts that float across a screen after a heart emoji has been sent in a message.

AR allows users to interact with real and virtual objects and is increasingly used in schools and universities to support teaching and learning (Kim & Kim, 2018). However, research addressing educational applications of AR technology has thus far prioritised school and tertiary education settings (Chen et al., 2017; Yuliono, Sarwanto & Rintayati, 2018).

AR technology offers students the potential to understand abstract concepts (Furió et al., 2013) and to visualise events that otherwise could not easily be explored in the real world (Chen et al., 2017). Examples of such learning includes projecting visual elements onto real objects to show a whale leaping out of the ocean and splashing back down again (No Time Like The Present [NTLTP], 2017), or observing a volcano or a hurricane from multiple persepctives (Google Education, 2019), all within the walls of a classroom. This is reported to enhance student motivation and concentration; enhanced interactions between students and content material, students as peers, and interactions between students and teachers (Akçayır & Akçayır, 2017). Further, AR is reported to provide opportunities for real-time feedback and scaffolding (Bacca, Baldiris, Fabregat & Kinshuk, 2018).

Here, we review extant literature that addresses AR in early childhood education and advocate for research that will determine whether the inclusion of AR technology as a cutting-edge form of digital technology has the potential to enhance play as the vehicle of active and interactive learning in the context of an informal, play-based curriculum.

Background

Emerging technologies have been described as having hype cycles (Gartner, 2018). Hype, in this context, refers to technology that is promoted as new and exciting, and for which there may be inflated expectations. The Gartner Hype Cycle for Emerging Technologies[1], is helpful in identifying the phases through which technological innovations progress. In 2018, 4D printing had passed the ‘Innovation Trigger’ and the ‘Plateau of Productivity’, and was theorised to be more than ten years away. Smart Robots and Quantum Computing were deemed

[1] *Gartner does not endorse any vendor, product or service depicted in its research publications, and does not advise technology users to select only those vendors with the highest ratings or other designation. Gartner research publications consist of the opinions of Gartner's research organization and should not be construed as statements of fact. Gartner disclaims all warranties, expressed or implied, with respect to this research, including any warranties of merchantability or fitness for a particular purpose*.

to be five to ten years away. Blockchain and Connected Home were similarly predicted to reach the 'Plateau of Productivity' in five to ten years. Interestingly, AR is significantly further ahead on the hype cycle than Quantum Computing, Blockchain and Connected Home, yet in 2019, Quantum Computing, Blockchain and Connected Home already feature frequently in media and advertising.

AR's increasing prevalence in digital technologies used in the home environment is significant for education. Marsh (2015) reported that in the United Kingdom, 37% of pre-schoolers aged from three to five years owned their own tablet computer – this does not include the number of pre-schoolers who did not *own* a tablet but had access to one. In 2019, one may assume that the figure of 37% has increased. Given that AR technology features in many smartphone and tablet apps, and that many pre-schoolers are regularly accessing digital devices, it is possible that AR is closer to the 'Plateau of Productivity', the phase when mainstream adoption occurs, than anticipated.

The use of technology in education is advancing rapidly and the range of digital technologies routinely used by young children is extensive (Edwards et al., 2018). As early learning professionals, early childhood teachers – and teacher-educators – need to be confident that the digital technologies included in early learning curricula are more than 'the flavour of the day'; as elements of a purposeful, play-based curriculum, technologies should be carefully selected to promote child learning through play. Education settings should be leading learning, rather than catching up with the technology already being used by children in the home environment.

Method

A review of the literature conducted by Akçayır and Akçayır (2017) found that 51% and 29% of studies respectively considered K-12 and university students as sample groups, but only 1% of studies were conducted with preschool children. In addition, Akçayır and Akçayır (2017) limited their review to a single journal database, the Social Science Citation Index (SSCI). This study aims to address that gap.

In the present study, the Educational Resources Information Centre database (ERIC), ProQuest, and the Web of Science have been included as these databases are well established in Education research, index a wide variety of free peer-reviewed and full-text materials and provide access to high quality research literature.

In order to take a systematic approach to this review of the literature, we followed Arksey and O'Malley's (2005) five-stage methodological framework. First, research questions and

relevant studies were identified, studies were selected, data were gathered, summarised, and are reported.

Two research questions were identified:

1. Which AR technologies are most frequently used in educational settings?
2. What are the reported benefits of AR to early childhood education?

The search terms ‘augmented reality’ and ‘augmented reality and early childhood education’ were used to identify relevant studies. While conducting the research, no limitation was placed on the type of manuscript or date of publication. However, the language ‘English’ was chosen as the search parameter. In total, 16 articles – all published between March 2015 and November 2018 – were found. All papers were from peer-reviewed journals with the exception of a conference paper presented by Kotzageorgiou and colleagues (2018). The decision was made to include this paper as it met all the inclusion criteria (see Table 1). The recency of the publications is indicative of the newness of AR and its application in early childhood education.

Inclusion and exclusion criteria (Table 1) were then applied to each article to determine suitability for selection (Arksey & O’Malley, 2005). This reduced the number of publications from 16 to eight.

Table 1. Inclusion and exclusion criteria

Inclusion	**Exclusion**
1. AR in early childhood education settings	1. AR in other educational settings
2. Preschool children and teachers as main participants	2. Parents as main participants
3. Clear research design articulated	3. Ambiguous research design
4. Results are clearly defined	4. Results are unclearly defined

NVivo software was used to code study aims, participants, methodologies and type of digital technology employed: desktop computers, mobile devices (e.g. smartphone, tablet) or other devices (e.g, Kinect or specific equipment designed by the researchers). Reported benefits, challenges, limitations and suggestions were also coded. After undertaking a memoing process, data were summarised and are presented in Table 2, providing additional context for readers (Arksey & O’Malley, 2005).

Table 2 Data summary

Author(s)	Han, Jo, Hyun & So, 2015	Cheng & Tsai, 2016	Huang, Li & Fong, 2016	Safar & Al-Jafar, 2017
Study aims	Explored the affordances of 'AR-infused' robot systems for enhancing children's dramatic play	Investigated interactions during child-parent shared reading using an AR picture book; explored parents' conceptions of AR learning	Explored the feasibility of AR in early art education	Examined the effectiveness of AR for teaching and learning English alphabet
Participants	81 children (Five- to six-years- old)	33 child-parent dyads (Children five- to ten-years-old)	30 children (Four to five-years-old)	42 preschools
Country context	Korea	Taiwan	Hong Kong	Kuwait
Methodology	Mixed method (Experimental design)	Mixed method (Parent interview and dyad observation)	Design-based research (Semi-structured interview with the professionals and child observation)	Mixed-method (Quasi-experimental design)
Digital technology	Other (Robot)	Mobile device (Tablet)	Mobile device (Tablet)	Mobile device (Tablet)
Reported benefits	Increased satisfaction and sensory immersion	Enhanced learning motivation	Triggered imagination; Enhanced teaching of abstract concepts	Knowledge acquisition
Results	Higher level of interactive engagement and consequently an increase in children's interest and participation in learning	Child-parent shared reading AR book promoted a positive AR learning experience and enhanced children's learning	AR-based art activities promoted excitement, engagement and enjoyment among children. AR can be a powerful and motivating instrument to enhance instructions in a transformative way	Increased child interaction with an English alphabet lesson. Active engagement with teaching/learning processes led to higher achievement score
Reported study limitations	Duration of the experiment	Small sample size	Novelty effect; no initial exposure and experience provided to the participants before the research commenced	No limitation identified
Study recommendations	Need for further rigorous studies to show the possibilities of AR robot-assisted learning	A framework for employing child-parent shared AR book reading is suggested, which needs further evaluation in practice	The influence of AR technology on children's learning outcome in art education needs further evaluation	A need for delivering training courses for teachers on how to use AR in the classroom

Table 2 (Continued)

Author(s)	Yilmaz, Kucuk & Goktas, 2017	Kotzageorgiou et al., 2018	Yilmaz, 2016	Lorusso et al., 2018
Study aims	Examined children's attitudes towards AR picture book and their story comprehension performance; extended Cheng & Tsai (2016)	Investigated the feasibility of AR in supporting engagement, motivation and symbolic play of children on autism spectrum	Examined child behaviours while interacting with AR; investigated teachers attitudes towards AR	Explored the impact of AR app on children's cognitive and social skills
Participants	92 children (five- to six-years- old)	Three children on autism spectrum (six-years-old)	30 teachers and 33 children (five- to six-years- old)	25 children (four- to five-years-old)
Country context	Turkey	Greece	Turkey	Italy
Methodology	Quantitative (Explanatory design)	Qualitative (Non-participative observation)	Mixed method (Descriptive, content and correlational analysis)	Mixed method (Structured observation and teacher questionnaire)
Digital technology	Desktop computer	Mobile device (Mobile phone)	Mobile device (Tablet)	Mobile device (Tablet)
Reported benefits	Concept acquisition	Supported symbolic play	Provided real and 'magical' sense	Facilitated social interaction
Results	Positive child attitudes towards AR picture book. However, when enjoyment increased, story comprehension decreased	Child persistence, concentration and creativity observed; AR also supported the emergence of symbolic actions by children with autism	Teachers had a positive attitude toward AR and perceived it to be useful and easy to use; AR also promoted children's behaviour and interactions through pointing, responding and inspecting the device	Elicited high levels of participation and social interaction. AR app was easy to understand. Child engagement and cooperation improved following familiarisation with app.
Reported study limitations	Prior experience vs novelty not considered in the study	Small sample size	No limitations identified	No limitations identified
Study recommendations	Further research to examine the relationship between enjoyment and learning performance	Future experimental research to determine contribution of AR to symbolic play skills of children with/without ASD	Further research to investigate child behaviour while using AR	Further research to test the impact of AR on children with neurodevelopmental disorders

Results and Discussion

In line with the methodological framework employed (Arksey & O'Malley, 2005), we address the research questions in turn.

Which AR technologies are most frequently used in educational settings?

In the initial search, sixteen articles were identified that included AR technology. However, only eight articles met the inclusion criteria. Six of the eight studies reviewed found mobile devices to be the preferred platform for AR technology to supplement teaching and learning. In the reviewed studies, a variety of digital devices were used to access AR. These included desktop computers, tablets, smartphones and in one study, robots. However, the ways in which AR was used and the extent to which it was used, were influenced by the types of digital devices employed. Whilst this review of the literature equipped us to answer this research question, there is an urgent need for further research in this area.

What are the reported benefits of AR to early childhood education?

The studies reviewed suggest that the use of AR improved child learning outcomes: during dramatic play (Han, Jo, Hyun & So, 2015), shared book reading (Cheng & Tsai, 2016), art activities (Huang, Li & Fong, 2016) and alphabet learning (Safar & Al-Jafar, 2017). AR supported child engagement (Han, Jo, Hyun & So, 2015), persistence, concentration and creativity (Kotzageorgiou et al., 2018), motivation (Cheng & Tsai, 2016; Yilmaz et al., 2017), excitement and enjoyment (Huang, Li & Fong, 2016; Yilmaz, 2016;), and supported high levels of social interaction and participation (Lorusso et al., 2018). Huang and colleagues (2016) reported that concept acquisition was supported by the use of AR objects as children were able to explore AR objects from different perspectives, supporting findings from comparable studies conducted in school and tertiary education settings (Chang et al., 2015; Furió et al., 2013).

Each of the eight studies took an implementation approach. However, only two studies included post-implementation assessment of the impact of AR technology on child learning (Safar & Al-Jafar, 2017; Yilmaz et al., 2017). Further, only three of the studies included teachers as co-researchers (Huang et al., 2016; Lorusso et al., 2018; Yilmaz, 2016) and no study provided suggestions about how AR technology could be incorporated in informal, play-based early childhood curricula to enrich pedagogical practices. This is an area that needs to be further addressed, given the pace with which children and education settings are influenced by technological advancements. Further, there is a need for more research to examine the impact of AR technology on child outcomes in the context of play-based learning.

Interestingly, Han and colleagues (2015) provided children with an opportunity to familiarise themselves with the AR technology prior to commencing data collection. As such, it would be important to examine whether novelty contributes to increased interest and engagement in AR and further investigation is necessary to determine whether AR improves engagement when novelty is not a factor.

Some studies have reported limitations. In particular, these related to technical difficulties such as the placement of the real-world objects in fixed positions in order to be triggered by AR apps and the lighting of the room (Kotzageorgiou et al., 2018), highlighting the need for professional learning for educators to support the the inclusion of AR technologies in early childhood education (Huang et al., 2016).

Conclusion

In the 21st Century, digital technologies are an important element of early childhood curricula (DEEWR, 2009; Grieshaber & Yelland, 2005). Traditional early childhood pedagogies will adapt as 'play' and the nature of interpersonal interactions evolve in response to environmental influences and objects: a three-year-old using AR in the form of a filter to add rabbit ears while taking part in an online video chat would have been unimaginable even five years ago.

Augmented reality, as one form of digital technology, is already being used in schools and tertiary education to expand opportunities for learning, however there is a need to explore whether the inclusion of AR technology in early childhood education will increase pedagogical quality and enrich learning.

There is a need to gather evidence regarding the influence of AR technology on play and social interaction rather than making assumptions about whether it helps or hinders play-based learning. However, if early childhood education settings are to lead learning, it is first necessary to determine whether AR will raise the quality of play-based learning, or whether like Tamagochis and Pokémon GO, augmented reality will be here today but gone tomorrow.

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