Numeracy Learning with Digital Play in Early Childhood Settings

by

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Abstract

Advances in digital technology have seen a proliferation of touch screen interfaces available to young children. These screens have changed the way in which young children engage with digital technology; with increased exposure and use, it raises debates about the suitability of integrating digital technology within early childhood settings. There are limited empirical studies that investigate the appropriateness of emergent digital technology within the field of early childhood. Thus, this study explores: a) early childhood stakeholders' attitudes towards the use of digital technology, b) the developmental appropriateness and role of numeracy Apps designed for 3-4 year old children's numeracy development/learning, c) 3-4 year old children's engagement with, and enjoyment of, digital technology, and d) whether and to what degree 3-4 year old children's engagement with Apps via touch screen technology develops their ability to learn numeracy outcomes.

This study used a mixed-methodological approach consisting of three phases of investigation. Phase 1: Surveying stakeholders (child care educators and parents) to explore their attitudes towards the potential integration of digital technologies within child care service delivery. Phase 2: Reviewing Apps designed for 3-4 year old children's numeracy development to evaluate their age-appropriateness and educational capacity. Phase 3: Observing 3-4 year old children playing with these Apps and analysing their learning.

The findings of this study indicate that early childhood educators were in favour of using digital technology, however did not feel they were adequately trained or had the resources for successful integration. The most popular numeracy Apps for young children were found to be developmentally inappropriate and instructive in style, using drill and practice techniques. Despite the instructive design of numeracy Apps, this study found that young children's numeracy learning outcomes were improved. The implication of these findings points to a need for a pedagogical model to successfully integrate digital technology within early childhood settings. The Digital Play model is discussed.

Statement of Original Authorship

I declare that:

This thesis presents work carried out by myself and does not incorporate without acknowledgment any material previously submitted for a degree or diploma in any university; to the best of my knowledge it does not contain any materials previously published or written by another person except where due reference is made in the text; and all substantive contributions by others to the work presented, including jointly authored publications, is clearly acknowledged.

Signature:

Date: 18-November-2016

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Kids, you get your Dad back at night-time now.

Chapter I: Overview of the Study

1.1 Introduction

The thesis addresses whether emergent digital technologies, specifically gestural interfaces can be used as a learning tool to support 3-4 year old children's numeracy development. Firstly, the attitudes by educators and parents towards the integration of digital technology into early childhood settings are investigated. Secondly, the developmental appropriateness and function of numeracy Apps for 3 to 4 year old children is assessed. Finally, children's learning and engagement with numeracy-based Apps are explored.

The field of early childhood is divided regarding the integration of digital technology. There is concern that the potential integration of digital technology could alter the field of early childhood to its core and there is resistance to its adoption. However, digital technology is becoming part of children's day-to-day milieu and part of their educational and working futures. To understand the impact of digital technologies within early childhood, a mixed methodological approach is used. The research involves three sequential phases in design: Phase 1 covered attitudes of early childhood stakeholders (parents and educators) towards the integration of digital technology; Phase 2 measured developmental appropriateness and function of Apps for preschool numeracy learning; and Phase 3 measured children's engagement, enjoyment and numeracy learning pre and post use of digital technologies within play-based learning environments. There is currently limited empirical research analysing the appropriateness of emergent digital technology within early childhood settings, impacting understanding of the role of emergent digital technology within the field. Rather, debates have tended to be theoretical in nature and revolve around ideological positions of early childhood and play.

This study provides empirical data which can inform the integration of digital technologies in early childhood settings. Furthermore, analysis in this study addresses whether the use of digital technologies can constitute a pedagogical model within early childhood education, this being digital play. In the course of this study a number of conference proceedings were

published, which can be obtained from relevant organisations and have been included within Appendix P.

1.2 Background to the Study and the Research Questions

Early childhood is seen as a time of great change within an individual's holistic development, with the early years seen as a time for children to develop "a capacity to learn" (Australian Children's Education and Care Quality Authority [ACECQA], 2014). Children who receive high-quality early childhood education services are lead to "better health, education and employment outcomes later in life" (ACECQA, 2014). The value of high-quality early childhood education is undeniable; rather the question turns to what constitutes best practice within the early years and how this translates to current early childhood educators who help guide the sector and allow for growth and change. A recent change within the field of early childhood is the growing use of digital technology, be it in the home or care environments. Whilst digital technologies have commonly been used in university education, primary and middle school environments, their use in the early years has been limited. This has primarily been due to the limitations of digital technology for young children, often involving passive one-way communication methods (e.g. television, video) or requiring too much of children's limited fine motor capacities (e.g. standard desktop/laptop computers with mouse and keyboard setups) (Bower, 2012; Kucirkova, Messer, Sheehy & Fernández Panadero, 2014; Plowman & McPake, 2013). However the advent of emergent digital technologies that require more of children's sensory inputs as well as greater interface control (e.g. gestural interface devices such as iPad) is changing children's use of digital technology to resemble children's play rather than passive observation.

Despite the potential of digital technology, there is still trepidation about the integration of such technology from the early childhood community, with little separating emergent digital technologies from pre-existing non-early childhood friendly tools. Rather, debates have focused on the changing nature of childhood with little emphasis on a delineation of the sorts of digital technologies children are being exposed to within their home environments. There is an undercurrent of thinking that the sudden rise in digital technology use by young children is drastically altering the landscape of early childhood, to its detriment. As the integration of emergent digital technology is still in its infancy, it is essential that educators and parents are

surveyed to identify pre-existing attitudes and current beliefs on the role and value of digital technology within early childhood. This will allow for training and education packages that help identify misconceptions and misinformation that may exist about digital technology with young children.

It is essential that, at the early stage of digital technology integration, policy makers, educators and parents are provided with empirically based evidence that can validate whether these devices are developmentally appropriate and if young children can learn from digital technology. Empirically based findings will assist educators and parents with their choices rather than relying on pre-existing conceptions of how children learn as well as their perceived value of digital technology. Moreover, within the area of numeracy learning, digital technologies are also considered a tool to achieve numeracy learning outcomes. Thus, it is important to develop approaches in building theoretical foundations in using appropriate digital technology to assist educators understanding of how to support children to engage with and enjoy their learning through digital technology to promote numeracy learning. These questions will be addressed to inform the field of early childhood on how to address the complexities of digital technology integration. The following research questions and sub-questions directed the study:

1. Are digital technologies being used with children aged 3-4 and what are the prevailing attitudes that child care educators (directors, teachers and carers) and parents have towards the integration of digital technology?
    1.1. Do child care educators (directors, teachers and carers) and parents believe that gestural interface devices are developmentally appropriate for preschool education or not?
    1.2. Do child care educators (directors, teachers and carers) and parents believe that Apps (software) designed for preschool education are developmentally appropriate or not?

2. What are the primary roles of the most popular Apps designed for preschool aged children's numeracy learning and are the Apps designed developmentally appropriate for children?

3. To what level do 3-4-year-old children engage, enjoy, and learn numeracy concepts via play with gestural interface devices?
    3.1. To what level are 3-4-year-old children engaged with games using a gestural interface

device?

3.2. To what level do 3-4-year-old children enjoy using games via a gestural interface device?

3.3. To what degree does the use of games using a gestural interface device have on 3-4-year-old children's ability to learn numeracy concepts?

1.3 Significance of the Study

This research is significant for a number of reasons. Firstly, it provides an overview of what digital technologies are currently being used with young children both in home settings and within child care. This helps early childhood stakeholders identify if children are being exposed to a wide array of digital technologies and how often they use them. This facilitates early childhood educators to identify the educational tools children are being exposed to within the two settings and highlights the differences, allowing for an understanding of how children may be learning at home as opposed to care settings.

Furthermore, this study analyses parents' and educators' attitudes towards the integration of gestural interface devices and associated Apps, providing valuable insight into the current mindset of the early childhood community in relation to potential integration and training and education requirements. Additionally, this study analyses various methods in appraising Apps designed for a preschool audience, focusing on developmental appropriateness and role of numeracy Apps. As such it allows both parents and educators to identify the strengths and limitations of numeracy Apps in relation to age-appropriateness and learning outcomes for three to four year old children.

Finally, the research provides clear, empirically based evidence about young children's engagement, enjoyment and numeracy learning when using gestural interfaces and numeracy Apps. This informs parents, educators, quality assurers and App developers about the potential impact of digital technology within early childhood settings, thereby reshaping philosophical debates about appropriateness, and grounding arguments in evidence. There are few international and Australian studies that validate the use of gestural interface devices on numeracy learning for preschool aged children. This study demonstrates that the use of digital technology is indeed an appropriate pedagogical option for parents and educators and its use should be encouraged. This study also establishes that digital technologies using gestural

interfaces meet the tenets of becoming a pedagogical approach to learning within the early years, that being digital play. In this study, digital play is defined when there is an integration of early childhood contexts, play-based learning and digital technologies that merge to influence children's enjoyment and engagement within learning to facilitate curricula outcomes (see Section 2.7.4).

1.4 Organisation of the Study

The methodological approaches of this study were based on both quantitative and qualitative research. It was conducted in three phases, these being Phase 1: Survey Phase, Phase 2: App Review Phase and Phase 3: Children's Play Phase. A diagrammatical representation of the organisation of these phases can be seen in Figure 3.1.

1.4.1 Survey Phase

A survey investigated early childhood educators working in child care centres and young children's parents attitudes towards the use of digital technology within the home and service delivery. The survey design was based upon research by Chen and Chang (2006), Fogarty, Cretchley, Harman, Ellerton and Konki (2002), and Funk, Brouwer, Curtiss and McBroom (2009) and Li (2006). Five parents and five educators participated in a pilot study which identified numeracy as the area in which they believed children could learn most from the use of gestural interface devices, and was thus chosen the curricula area for Phase 3. In the onsite survey 80 parents and 49 educators participated from two child care services in South Australia and one from the Northern Territory. The survey had three major sections: collecting demographic information, parental/educator confidence in using technology, digital technologies accessed and used within home and care and attitudes towards the integration of digital technology. Both educators and parents were asked if they believed that Apps utilising gestural interfaces devices were developmentally appropriate for young children (leading to Phase 2) and if they believed gestural interface devices could be used to teach young children (leading to Phase 3).

1.4.2 App Review Phase

Phase 2 was an App review phase, with 50 numeracy Apps reviewed from the most popular category of the Apple website Game Centre. Apps were reviewed using the instruments of Gestural Interface App Rating Scale (GIARS) (see Section 3.2) which was created based on

the Haugland/Gerzog Developmental Scale (Haughland & Wright, 1997) to determine developmental appropriateness. This finding was compared to parents' and educators' perception of Apps from Phase 1. The five highest scoring Apps within GIARS were used within Phase 3. The Math App Appraisal Scale (MAAS) (Handal, Campbell, Cavanagh & Dave, 2014) (see Section 3.2) was used to determine the primary role of each App.

1.4.3 Children's Play Phase

Phase 3 was an onsite observational phase within the child care centres from Phase 1. The phase explored children's level of engagement, enjoyment and numeracy learning whilst using iPads loaded with the five most developmentally appropriate numeracy Apps from Phase 2. Eighty children participated in the study and all their parents completed surveys from Phase 1. At each centre there was a four-week data collection period: week one involved pre-testing numeracy outcomes based upon measurement tools from Ramani and Siegler's (2011) and Segal's (2011) studies and enjoyment based upon Airey, Plowman, Connolly and Luckin's (2002) study, as well as familiarising children with the gestural interface using non-numeracy Apps. Weeks two and three involved children's play with numeracy Apps whilst recording engagement and relevant observations to children's play with the iPad via the Involvement Scale (Department of Children's Services [DECS], 2008, p. 81). Week four involved post-testing numeracy outcomes and enjoyment.

1.5 Structure of the Thesis

1.5.1 Chapter 2: Literature Review

An overview of the field of early childhood education and settings designed to support the education and care of children in preschool environments provides the contexts in which the integration of digital technologies is discussed. Integration of digital technology is grounded within the theoretical model of Technological Pedagogical Content Knowledge [TPACK] (Angeli & Valanides, 2005; Mishra & Koehler, 2006), which provides a framework for this study to provide the practical and theoretical basis for integration. As the use of digital technology is a controversial topic for the early childhood community, the acceptance or non-acceptance of technology is framed within the widely used scale, the Unified Theory of Acceptance and Use of Technology 2 [UTAUT2] (Venkatesh, Thong & Xu, 2012). It is not expected that the early childhood community will embrace digital technology, regardless of

perceived benefits, therefore an overview of the potential challenges and key reasons for integration allow for an analysis of participants' responses. Children's potential numeracy learning outcomes via engagement with digital technologies informs analysis of both the tools of use and subsequent potential numeracy learning outcomes. The questions raised within the study are framed with the Digital Play model outlined in Section 2.7.4, evaluating if the integration of digital technologies has the potential to become its own pedagogical approach within early childhood, digital play.

1.5.2 Chapter 3: Research Methodology and Design

This chapter describes the research rationale and research design of the present study for each of the three research phases. It provides detailed information on the questions that guided the research, justification of research methodologies, participants, instruments, procedures, data collection and analysis methods, as well as ethical considerations.

1.5.3 Chapter 4: Findings of the Questionnaire Survey Phase

This chapter reports the qualitative and quantitative findings from the survey of children's parents and the early childhood educators. The educators include directors, teachers and carers. Findings are reported in four sections: (a) demographic characteristics of parents and educators, (b) parents' attitudes or opinions about use of digital technology in early childhood education, (c) educators' attitudes or opinions about use of digital technology in early childhood education, and (d) differences and similarities between parents and educators' attitudes or opinions about use of digital technology in early childhood education. A summary of key points is provided with pertinent links to Phases 2 and 3.

1.5.4 Chapter 5: Findings of App Review Phase

Chapter 5 reports the qualitative and quantitative findings from the App review phase from early 2013. These include: (a) the characteristics of the chosen 50 Apps, (b) a review of their detailed ratings within GIARS, (c) the relationships in the nine areas and price range in GIARS, (d) the Apps' ranking in MAAS and, (e) the relationship between Apps ranking in GIARS and MAAS and the Apps' cost. Five of the top ranked Apps in GIARS were selected according to developmental appropriateness to be used in Phase 3.

1.5.5 Chapter 6: Findings of Child Play Phase

This chapter presents the qualitative and quantitative findings from the observations conducted in the child care centres. It reports on the following findings: (a) demographic characteristics, (b) children's engagement in playing with the Apps, (c) children's numeracy abilities, (d) children's selection of Apps, (e) children's interaction with other children while playing, (f) children's enjoyment in playing, (g) other factors that influence children's playing, (h) factors from child care centres and parents, (i) children's engagement in playing and their demographic background, and (j) children's numeracy improvement compared with their characteristic factors and playing activities in observation in child care centres. Summaries of the key points are addressed, and are examined within the discussion chapter.

1.5.6 Chapter 7: Discussion

Chapter 7 addresses the findings in relation to the research questions and major findings, and is framed within the Digital Play model (see Section 2.7.4). This chapter emphasis the digital technologies already used by educators and parents and the corresponding attitudes towards future integration. Educators' and parents' attitudes are evaluated by the findings from the App review and children's play phases, highlighting potential congruence or disconnection in the thinking of educators and parents towards digital technology. The chapter also argues that emergent digital technologies, such as iPads utilising gestural interfaces, should become a pedagogical model in its own right, which can be labelled digital play.

1.5.7 Chapter 8: General Conclusion

The integration of emergent digital technologies for young children's learning is a process presently being debated by the early childhood community. This chapter discusses that integration with respect to the realities observed within the course of the research. The study considerations are identified in this chapter. Implications of the research are identified and recommendations for further research are suggested. This chapter concludes with a summary statement of the present study.

1.6 Summary

As digital technologies continue to emerge as viable options for children's learning and in turn become their own pedagogical approach to learning, digital play. This research is a timely indication of the attitudes held by the community towards the potential integration of

digital technology and the reported benefits and concerns associated. Knowledge from Phase 1 will allow an insight into the thinking of the early childhood community regarding the integration of digital technology into early childhood. Phase 2 will provide detail as to the developmental appropriateness of popular numeracy Apps for young children, as well as their role and function. Finally, Phase 3 will empirically validate if children can learn numeracy skills via use of digital technologies and, furthermore, if children are engaged and enjoy using emergent technologies.

Chapter II: Literature Review

2.1 Introduction

This chapter is grounded within the Technological Pedagogical Content Knowledge [TPACK] framework (Angeli & Valanides, 2005; Mishra & Koehler, 2006). Based on the TPACK framework, there are three primary components that will be discussed: (a) early childhood education, (b) digital technology designed for young children and (c) young children's numeracy learning. The relationship between the three areas is investigated within the framework provided by TPACK to provide contextual information for the current study. The chapter begins by defining TPACK and each subsequent topic is grounded within the TPACK framework.

2.2 TPACK

There are a number of models that can be considered for educators' successful integration of digital technology, these include Diffusion of Innovations, Substitution Augmentation Modification Redefinition [SAMR] and TPACK (Phillips, 2015). Each allows for insight into how digital technology can and has been used within educational environments. Within the field of education, the TPACK model is used by educators to understand the relevant areas of knowledge that should be considered when implementing new digital technologies into teaching contexts (Chai, Koh, Tsai & Tan, 2011). Niess (2011, p. 300) describes that TPACK 'is a framework for thinking about the knowledge teachers need for making instructional decisions with respect to integrating digital technologies as learning tools'. The TPACK model allows for an understanding of the forms of knowledge educators must enact for successful integration, whilst the User Acceptance of Information Technology 2 (UTAUT2, see Section 2.8) model (Venkatesh, Thong & Xu, 2012) allows for dissemination of the barriers for such integration. Hence the two models allow for a comprehensive understanding of digital technology integration.

There are eight different domains of knowledge within TPACK. These are technological, pedagogical, content, technological pedagogical, technological content, pedagogical content, technological pedagogical content and the overarching domain of context (See Figure 2.1).

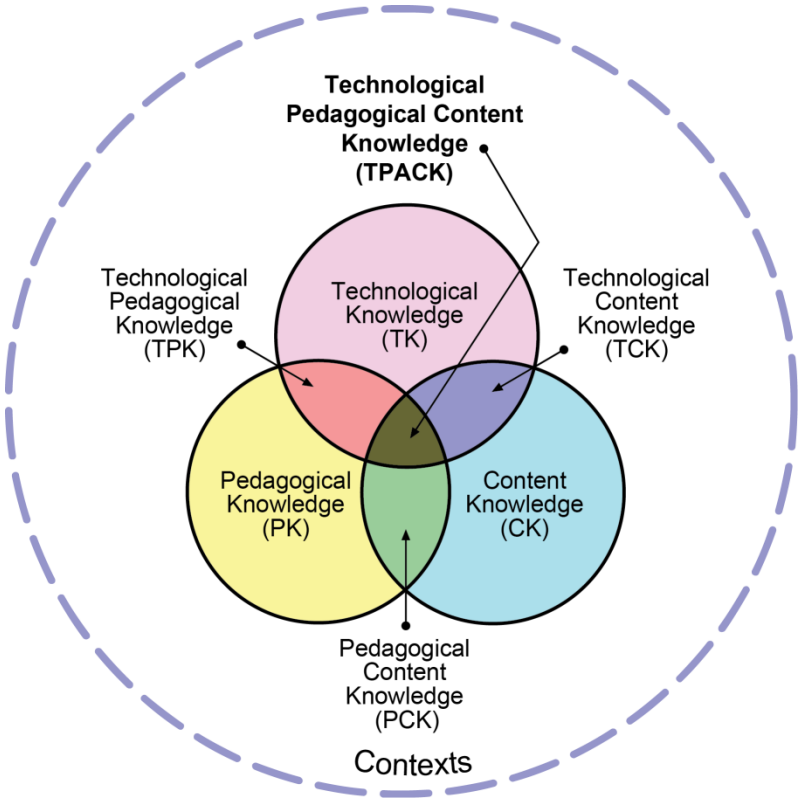

Figure 2.1. The TPACK model (http://tpack.org).

The TPACK model was adapted to suit the specific domains of the study (See Figure 2.2).

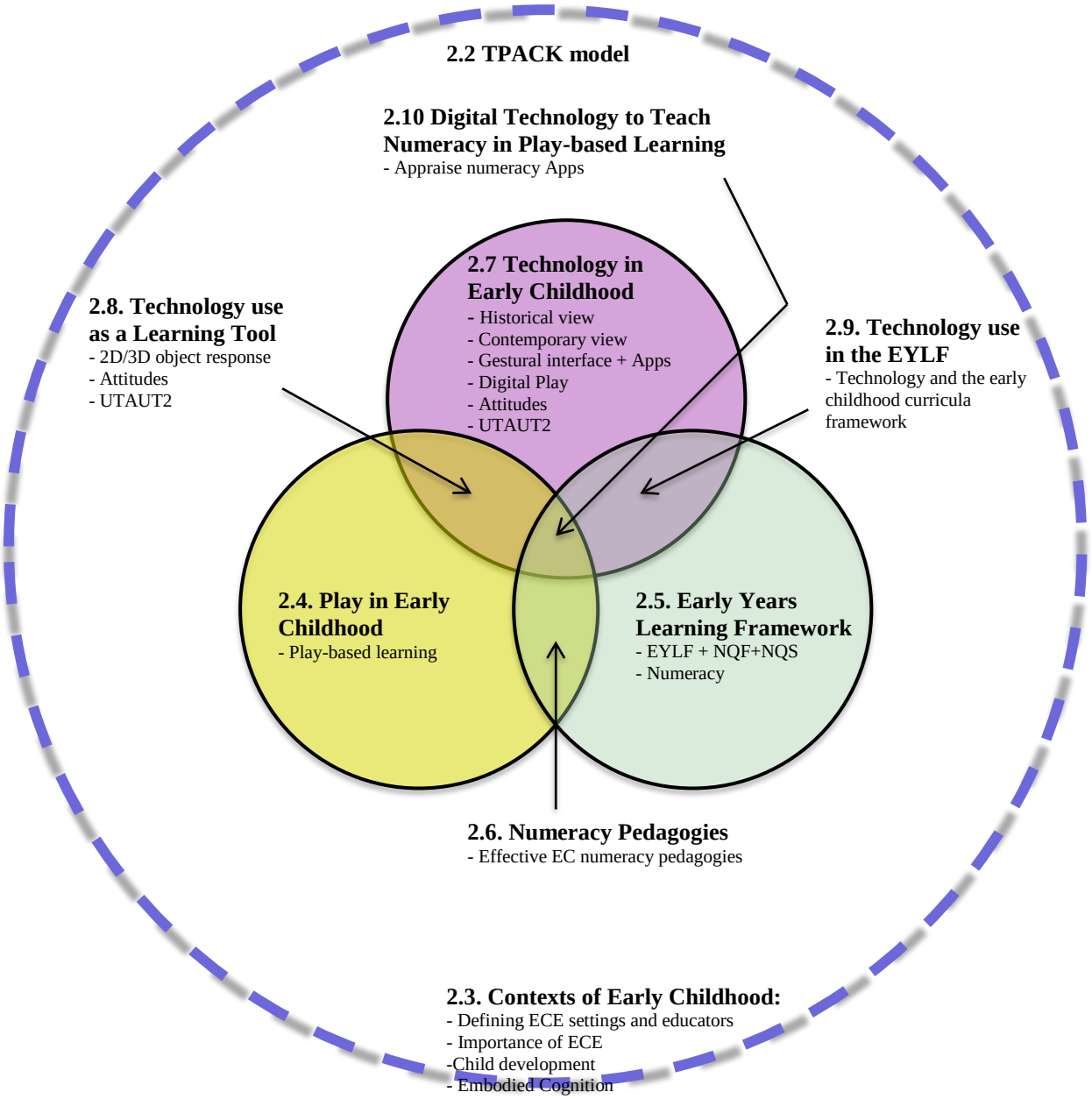

Figure 2.2. Adapted TPACK model.

As framed within the TPACK model, this review will explain the contextualised environment of early childhood education, including defining early childhood education as a term, the settings designed for early childhood education and the educators who work within these

settings. The importance of early childhood education within the nature of life-long learning will then be addressed, including determining the developmental capacities of children aged three to four years. The review will transition to outlining the play-based pedagogical approach used within Australian early childhood settings. The next section will discuss the Early Years Learning Framework [EYLF], the National Quality Standards [NQS] and the National Quality Framework [NQF] with a focus on numeracy. As this research focused on children's learning numeracy outcomes, effective numeracy pedagogies used within early childhood education will also be described.

The use of digital technology with young children will be discussed, presenting an overview of the tensions between young children and digital technology. The review will highlight the current platforms of digital technology with young children, concentrating on the advent of emergent digital technologies such as gestural interfaces and Apps. The review will also pose the question of whether emergent digital technologies with childhood friendly interfaces can become their own early childhood educational model. This will be framed with the proposed Digital Play model, thereby reclassifying children's use of digital technologies into digital play.

With the rise in popularity of digital technology the next section will also begin the process of analysing barriers and attitudes that exist towards the integration of digital technology into early childhood. This will be categorised within the Unified Theory of Acceptance and Use of Technology 2 [UTAUT2]. The following section will analyse the link between digital technology and the EYLF and, moreover, how Apps designed for numeracy development in the early years can be appraised to determine role and function.

Using the TPACK model, the review will bring all of the information together to discuss if and how digital technology is being used to teach numeracy in play-based early childhood settings. The final sections will discuss the development of the research questions as framed within the Digital Play model as well as providing a summary of the literature review.

2.3 Context of Early Childhood

The first level within the TPACK framework is the context of the educational environments in which the research was conducted. To understand the larger theoretical issues around the integration of digital technology into early childhood settings, it is important to define early

childhood, highlight its importance, outline the service delivery models for early childhood education and understand the developmental capacities of children within the age range. Within the delivery of early childhood education, Melhuish (as cited in Pendergast & Garvis, 2013, p. 5) highlights a number of key tenets that are most important for enhancing children's development. Factors most pertinent to this study include early childhood services having well-trained staff, continued staff development and a developmentally appropriate curriculum with educational content. The nature of educational institutions and the people who work within them play a very large role in the effective delivery of high quality education and care. The next section will define early childhood education and discuss service types and educators.

2.3.1 Defining Early Childhood Education, Settings and Educators

Specific definitions of early childhood education vary according to jurisdictional terminology. There is an understanding that early childhood education caters for children anywhere from zero to five years of age, but can extend to six (Ailwood, 2007). The EYLF defines children as 'babies, toddlers and three to five year[s] olds, unless otherwise stated' (Department of Education, Employment and Workplace Relations [DEEWR], 2009), consistent with Ailwood.

Education and care services are defined by ACECQA (2014, para. 7) as:

> *any service providing or intended to provide education and care on a regular basis to children under 13 years of age other than a service that is excluded under the National Law or Regulations.*

The EYLF (DEEWR, 2009, p. 45) defines early childhood settings as 'long day care, occasional care, family day care, multi-purpose Aboriginal children's services, preschools and kindergartens, playgroups, crèches, early intervention settings and similar services'. The Australian Government's report into access to early childhood education in Australia defines early childhood settings as 'kindergartens, stand-alone preschools, long day care settings (LDC) and early learning centres, as well as preschool programs within the independent sector' (Baxter & Hand, 2013, p. xiv).

Within early childhood sectors the role of directors and educators are paramount to the effective delivery of quality early childhood programs. An early childhood educator is

defined as a ‘practitioner who works directly with children in early childhood settings’ (DEEWR, 2009, p. 45). Educators within early childhood settings need approved early childhood teaching qualifications, as of September 2013. ACECQA (2014, para. 8) states that individuals holding a primary teaching qualification (which must at least have a focus on children aged five to eight), teacher registration in Australia (or accreditation in New South Wales), or an approved education and care diploma or higher qualification. There is no difference in qualifications between an early childhood educator and director, rather positions within the service are nominated and appointed based on workplace employment practices.

Within Australia the National Quality Standards (NQS) and governing body ACECQA attempt to control variance in the quality of care and education with early childhood settings. ACECQA (2014) is an independent authority within early childhood whose goal is to ‘inform the wider community about the importance of improving outcomes in children’s education and care’. ACECQA achieves this by rating early childhood services against the NQS and guides implementation of the National Quality Framework (NQF). Governmental regulations within the NQF have also led to a reported strain on the child care sector as it struggles to meet qualification requirements and there is a shortage of people wanting to work in the industry (Bainbridge, 2013). A balance between the ability to retain and grow staff and what constitutes high-quality care and education is vital when considering the growing amount of research into the value of early childhood education.

2.3.2 The Importance of Early Childhood Education

Agreement on early childhood education committed Commonwealth, state and territory governments to achieving universal access to preschool by 2013 (Baxter & Hand, 2013). The COAG report (Council of Australia Governments [COAG], 2009, p. 3) explains the importance of early childhood education:

> *Early childhood is a critical time in human development. There is now comprehensive research that shows that experiences children have in the early years of life set neurological and biological pathways that can have life-long impacts on health, learning and behaviour. There is also compelling international evidence about returns on investment in early childhood services for children from disadvantaged backgrounds, including the work of Nobel Laureate James Heckman.*

The COAG report demonstrates that early childhood is a critical time in human development. Berk (2013) explains that within the scope of human growth the period from birth to the age of five sees the most rapid rate of growth and development. To understand the change that children go through and to comprehend how this influences their ability to learn and develop using digital technology, this review discusses the developmental capacities and learning styles of children with a focus on the early years (birth to five years of age).

2.3.3 Developmental Capacities of Children in the Early Years

The period from birth to five years of age sees a rapid growth within the social and emotional, physical and cognitive domains of development (Berk, 2013). The following section will outline some of the key developmental milestones relevant to children's participation within the present study, which is the ability to learn numeracy skills via the use of digital technology. It should be noted that development is an intertwining holistic process whereby all domains are interconnected (Haynes, 2009; McDevitt & Ormrod, 2012). The study of child development encompasses a holistic view of the changing child; however, for ease of discussion, development is often broken into categories, these being: social and emotional, physical, and cognitive domains of development (Dodge, Colker & Heroman, 2002).

Social and emotional development is a broad domain of development that covers how children feel about themselves and others. It captures children's play, work and attachment experiences (Parke & Gauvain, 2009). It is important to note that by preschool age, children who are well adjusted socially and emotionally will be able to establish close relationships with playmates, cooperate with others, participate in group activities and show the ability to concentrate on and persist with challenging tasks, as well as listen to instructions and be attentive (Dodge et al., 2002; Gagnon et al., 2014; Marotz & Allen, 2013). Physical development is characterised by physical growth, refined motor skills and perceptual development (Lightfoot, Cole & Cole, 2012). During the early years children have many more neurons (brain cells) than they need. Through the process of pruning, children are able to strengthen active neural pathways whilst 'pruning' those of no use (Berk, 2013; Marotz & Allen, 2013; Sheridan, Sharma & Cockerill, 2008). Additionally, in the first few years of life children's brains are highly plastic in that they can reorganise specific functions of learning that the mature brain cannot (Berk, 2013, p. 187). Johnston (2009, p. 54) explains that 'children appear to learn more quickly than adults and can easily acquire new skills if

exposed early in life'; therefore early childhood is considered a time whereby new skills can be learnt rapidly. Research has indicated that brain size and composition is directly influenced by experience (Sylvester, 2010). Bath (2005, p. 146) explains that 'neuroscience confirms that those in closest contact with the child will have the most profound influence on the nature of brain growth and development'. Therefore, exposure to developmentally appropriate learning by nurturing adults during the early years will shape the way in which the brain grows and develops.

During the preschool years there is a shift in muscular development of fine and gross motor skills from the general to the specific (Harwood, Miller & Vasta, 2008). Children are able to refine motor skills leading to higher outcomes. Within the early years fine muscle development is slower than gross motor development, hence a need for a practice of such skills (Dodge et al, 2002). Thus, whilst motor refinement progresses during the early years, there are still limitations for early childhood researchers; for example, the analysis of children's artefacts to measure comprehension may be an inaccurate measure. For example, a preschool-aged child may have an idea in mind, but not yet possess the necessary fine motor skills to accurately represent this via an artefact (e.g. drawing), so the artefact does not reflect the child's true knowledge (Marotz & Allen, 2013). Hence, the instruments early childhood educator's use with children in the early years need to be cognisant of their developing fine motor control (see Section 2.7.3 for information regarding the use of gestural interface devices and young children's fine motor control).

As well as motor development, perceptual development becomes more refined with age. Three aspects of perceptual development – multisensory, habituation and sensory integration – are important for children to develop. Multisensory development is the child's ability to use more than one sense at one time. Habituation refers to a child's ability to focus on a task and not be distracted. Sensory integration is the child's ability to turn sensory information into a functional behaviour (Marotz & Allen, 2013, p.39). Perceptual development is tightly linked to mental processes commonly associated with cognitive development. For example, a typically developing four-year-old can sort, classify and pattern objects with various attributes (e.g. size, colour, weight); therefore children can use sensors to create schema regarding their environment in order to label and learn (Parke & Gauvain, 2009).

Whilst previous paragraphs discussed the physical aspects of brain development, cognitive development refers to the expansion of a child's intellect and mental abilities. It involves children recognising, processing and organising perceptual information so as to allow the child to understand their world (Dodge et al., 2002; Marotz & Allen, 2013). For the preschool-aged child, cognitive progression allows the evaluation of ideas, making judgments, solving problems, understanding rules, thinking ahead, and visualising possibilities and consequences (Marotz & Allen, 2013, pp. 39-40). Dodge et al. (2002, p. 21) describe three goals for cognitive development for the preschool-aged child, these being: (1) learning and problem solving, (2) thinking logically, and (3) representing and thinking symbolically. One of the most important tools for children to attain their goals and develop cognitively is that of language and speech.

Language development allows children to represent objects and ideas and includes understanding words, both verbal and written, with verbal being more predominant in early childhood and required in terms of children's ability to follow and complete tasks/learning (Dodge et al, 2002). Language development also constitutes multiple subsystems including sound, meaning, overall structure and everyday use (Berk, 2013). By developing receptive and expressive language, children enhance their cognitive, social, perceptual and neurological development (Marotz & Allen, 2013, p.41). Most 3 year olds are able to ask many questions and answer simple ones (Marotz & Allen, 2013) and most 4 to 5-year-old children are highly competent users of language (Mitchell & Ziegler, 2013). Children utilise language within play-based learning environments whereby language (verbal/written) is translated into physical play-based actions, allowing children to learn and develop, and is linked to the concept of embodied cognition.

2.3.4 Embodied Cognition

An important concept within the current research is the link between cognition and physical actions. This is owing to the gestural nature of iPads and Apps designed for children's numeracy learning. Action plays a central role in perception, acquisition and thought and that cognition is grounded in action (Rubichi, Riggio, Gherri & Nicoletti, 2011; Taylor, 2014). This notion finds relevance in the theory of embodied cognition. This form of cognition is founded on the claim that bodily-rooted knowledge involves processes of perception that fundamentally affect conceptual thinking (Barsalou, 2008; Segal, 2011). Embodiment

suggests that individuals engage with their environment using their bodies to interact with stimuli in a manner that helps the mind to lessen the cognitive load required of tasks (Wilson & Golonka, 2013).

The embodiment literature highlights that cognitive activity involves sensory-motor stimulation (Barsalou, 2008; Brouillet, Ferrier, Grosselin & Brouillet, 2011). Research shows that when individuals come into contact with stimuli they automatically simulate the sensory-motor response to that stimulus. As the stimuli is perceived and acted upon it creates a positive response in the individual's perception of the stimuli, influencing their affective judgement (Brouillet, Heurley, Martin & Brouillet, 2010; Jeannerod, 2006; Scorolli & Borghi, 2007; Taylor, 2014; Zwaan, 2008). Furthermore, when there is compatibility between the motor requirements of the stimuli and the motor response of the individual there are gains in reaction time known as Action Compatibility Effect [ACE] (Glenberg & Kaschak, 2002). For example, research has shown that ACE generates a genuine affective reaction that is positively marked (Cannon, Hayes & Tipper, 2010).

Early childhood pedagogies acknowledge that actions and bodily experiences are fundamental to cognitive processing, consistent with the concept of embodiment, whereby the young child learns through physical actions within the environment (Wellsby & Pexman, 2014). Educational approaches and theorists, such as Montessori and Piaget (cited in Berk, 2013), assert that physical movement and touch enhance learning. Therefore, it is important to understand why repeated physical actions can influence cognitive understanding. The direct link between embodied cognition and the research tools used in the current study will be further explained in Section 2.7.2. The next section expands on the specific early childhood pedagogies employed by educators to enhance children's learning and development.

2.4 Pedagogical Knowledge – Play in Early Childhood

Regardless of one's understanding of child development, every child is an individual and each child will follow a divergent path to achieve developmental outcomes. Variations in gender, temperament, interests, learning styles, life experiences, culture and special needs provide the individual differences that make each child unique, and it is difficult to predict developmental pathways and outcomes (Dodge et al., 2002). It is imperative that educators

understand children's holistic development and variances in order to effectively plan appropriate, meaningful experiences for them. The TPACK model refers to pedagogical knowledge as 'knowledge of how to plan instructions, deliver lessons, manage students and address individual differences' (Chai et al., 2011, p. 1185). The following section will discuss early childhood pedagogies that are considered developmentally appropriate and widely used with children aged from birth to five years old.

The EYLF explains that pedagogies refer to the 'practices that are intended to promote children's learning' (DEEWR, 2009, p. 46). Stephen (2010, p. 17) explains that early childhood educators' pedagogies are associated with 'teaching through modelling, prompting exploration, questioning, scaffolding specific skill acquisition and nurturing a child's disposition to learn'. The educator must therefore decide upon which pedagogies are most effective for the manner and style their contexts dictate. One of the biggest differences between early childhood education and primary education is the manner in which educators address children's learning. Early childhood focuses on child-centred learning, initiated by the child during play and supported by other children and adults, compared to primary education, which is subject driven and facilitated by the educator (Gonzalez-Mena, 2013; Yelland, 2011). Play-based learning is promoted within the EYLF, which states that children 'organise and make sense of their social worlds, as they engage actively with people, objects and representations' whilst engaged with play (DEEWR, 2009, p. 46).

According to Fleer (2017), classical theories of play from the nineteenth and twentieth century (surplus energy theory, relaxation and creation theory, practice theory and recapitulation theory of play) highlight that children's play was very instinctual, an activity that allowed them to release additional energy and practice the skills necessary for their transition to adulthood. A change in thinking, brought upon by Jean Piaget influenced modern understandings of play. In that children's play is a developmental process and that as children interact within their worlds it allows them to consider how the objects and artefacts fit within their pre-existing understanding (accommodation) and alter their schema or thought patterns and behaviours moving forward (adaptation) (Jones & Reynolds, 2011). There are numerous models of play from theorists such as Bateson, Burghardt, Miller and Almon, Parten, and Smilansky (cited in Fleer, 2016) that outline the categories or stages in children's play, many of which shape current understandings of the developmental importance of play. The concept

of play takes on a powerful meaning which has implications across lifespans and cultural practices; to specifically define play becomes problematic, as the functions of play become different dependent on cultural context (Ebbeck & Waniganayake, 2016). To problematize further, the contextualised period in which many of the current theories of play evolved do not reflect the current changes in technological advancements. In that, many of the models of play which are currently used do not consider that children of today have access to technology and travel methods that allows them to process information faster and with more reach than ever before (Fleer, 2017). Therefore, play needs to be considered within the changing landscape of the impact of digital technology on children.

From a developmental perspective, experts believe that symbolic and imaginative play provides the foundations for all domains of development (Ebbeck & Waniganayake, 2010). Gonzalez-Mena (2013) justifies the use of play for children by explaining that play is a 'developmentally appropriate practice', and it directly relates to children's stage of development as defined by theorists. Moreover, within early childhood settings 'play and learning are inextricably woven together; play is intrinsically motivated and powerful for children in all cultures' (Ebbeck & Waniganayake, 2010, p. 5) and play allows children to understand the emerging digital technological and communicative environments in which they will grow (Bulunuz, 2013; Wood & Jocius, 2014).

Other research, however, indicates that there is a growing concern about the value of play and the ability to clearly define what play is and what benefit it holds for young children, especially in relation to the value of play over more structured work, such as drill-repetitive practice (Lim, 2010; Yelland, 2011). These pressures on play arise from the concern within society that play does not provide for the more academic rigors that structured teacher directed academic work does (Fleer, 2013). Nevertheless, research clearly shows that play within the early years provides a meaningful and culturally responsive practice (Beckley, 2012; Fleer, 2013; Lim, 2010; Yelland, 2011). Whilst a clear definition of play is difficult to articulate, for the purposes of this study a clear definition of play needs to be determined in order to articulate play as being disparate from work, to help determine if digital technology integration reflects play appropriately. Gonzalez-Mena (2013) describes five characteristics which make play different from work. According to Gonzalez-Mena (2013) play involves: (1) active engagement, (2) intrinsic motivation, (3) attention to the means rather than the ends,

(4) nonliteral behaviour, and (5) freedom from external rules, and will serve as the definition of play for this thesis.

The concept of children's active engagement is pertinent to the present study. Goldspink, Winter and Foster (2008) explain that engagement is the level of participation and intrinsic interest that a child displays and involves both behaviours (such as persistence, effort, attention) and attitudes (such as motivation, positive learning values, enthusiasm, interest and pride in success). Measuring children's engagement during environmental interactions allows the researcher to measure child outcomes as well as program quality within the early years (Kishida & Kemp, 2006). Another term for engagement is involvement. Vygotsky (1978) explains that a person who is totally involved in their activity works to the limits of their abilities within their Zone of Proximal Development (ZPD), in the case of this study it's children's involvement during play. Laevers (2000) argues that involvement only occurs for children when the activity meets the capabilities of the child. Laevers (2000) describes involvement as a 'state of flow' for the child within an activity and suggests that involvement in children is usually found during play. The Department of Education and Children's Services (DECS, 2008, p. 81) describes nine indicators that a child participating in an activity is indeed 'involved'; they include: (1) concentration, (2) energy, (3) complexity/creativity, (4) facial expression and posture (non-verbal), (5) persistence, (6) precision, (7) reaction time, (8) verbal utterances/language, and (9) satisfaction. It is important to note that whilst a child is involved or engaged in an activity they may not actually show physical signs of enjoyment, such as smiling, however they may still have a sense of enjoyment from the activity (Fleer, 2013; Gonzalez-Mena, 2013).

The concepts of an activity being enjoyable or 'fun' are terms often used by educators within early childhood settings. Defining these concepts is difficult due to the limited conceptual framework regarding the manner in which these terms are defined (Goetz, Hall, Frenzel & Pekrun, 2006). Nabi and Krcmar (2004) highlight that there is no agreed scholarly definition of enjoyment. However, enjoyment can be broadly defined as a 'pleasurable affective response to a stimulus' (Green, Brock & Kaufman, 2004). Terms such as 'enjoyment', 'fun' and 'like' are used in a variety of learning disciplines to explain why children decide to engage in self-selected activities. The primary issue with a concept that is difficult to define comes from how to measure the concept (Goetz et al, 2006). There is a range of both

qualitative and quantitative measures ranging from physically measurable attributes to questionnaires and surveys that allow the researcher to form an understanding of the participants' 'enjoyment' of an activity (McCarthy, Jones & Clark-Carter, 2008; Read, 2008; Vanden Abeele, Zaman & Vanden Abeele, 2008). Specifically, with young children who have limited reading and receptive/expressive language capacities, the use of pictorial rating charts becomes applicable (Airey et al., 2002; Read, 2008).

Within the current study, both engagement and enjoyment were measured in terms of children's interactions with digital technology. Children's engagement and enjoyment levels will be analysed to strengthen early childhood educators' understanding of the use of digital technology and specifically touch screen technology. According to Glenton (2012), a key issue for early childhood educators is how to plan to incorporate new digital technologies within a play-based learning system. Glenton (2012) argues that children have exposure to digital devices within the home and these devices are becoming a key component of their play and enjoyment, therefore educators must decide the most appropriate manner in which to incorporate these digital technologies into their educational settings. The current early childhood learning framework in Australia specifies that digital technology should be integrated into early childhood education (DEEWR, 2009).

2.5 Content Knowledge – Early Years Learning Framework

Historically, within Australia each state and territory has had its own curriculum framework to assist educators in making informed choices about appropriate educational practice with children in their specific age range. In July 2009, the Council of Australian Governments [COAG] endorsed the implementation of a national framework for Australia, this being the Early Years Learning Framework [EYLF] (Goodfellow, 2009). The EYLF may complement, supplement or replace individual state and territory frameworks; the exact relationship will be determined by each jurisdiction (DEEWR, 2009, p. 5). According to a report commissioned by the Department of Education, Employment and Workplace Relations (Fleer, Shah & Peers, 2013) reaction to the EYLF has been positive within the early childhood community, with early childhood educators interested, but inexperienced users of the EYLF and long day care providers the most in need of training and information.

2.5.1 EYLF Structure

Within its structure, the EYLF has three underlying philosophical views of children pertaining to their growth and development, these being: (1) Belonging – where and with whom you belong, (2) Being – the here and now of the child, and (3) Becoming – the dynamics of change during childhood (DEEWR, 2009, p. 7). Relating to these three philosophical images of children, the EYLF lists three interrelated elements of children's learning, these elements being Principles, Practice and Learning Outcomes (DEEWR, 2009, p. 10). The majority of the EYLF addresses the Learning Outcomes, with Principles and Practices interwoven to illustrate best practice. Within the EYLF, five learning outcomes were designed to cover the age range of birth-5, these being: (1) children have a strong sense of identity, (2) children are connected with and contribute to their world, (3) children have a strong sense of wellbeing, (4) children are confident and involved learners, and (5) children are effective communicators (DEEWR, 2009, p. 19).

Within these elements are a range of pedagogical and curricula decision-making choices that early childhood educators must factor into their programs. For example, the learning outcome that 'children are confident and involved learners' includes that 'children resource their own learning through connecting with people, place, technologies and natural and processed materials'. An example to demonstrate this is that children 'use information and communication (ICT) to investigate and problem solve' (DEEWR, 2009, p. 37). One of the decisions that early childhood educators will need to consider within their implementation of curricula documents will be the manner and types of digital technologies to assist in curricula delivery. Section 2.7.2 will highlight the digital technological tools being used by educators within early childhood settings, whilst Section 2.9 will discuss the EYLF framework and the NQF suggestions about how educators can incorporate digital technology within best practice. The current study selected the numeracy curriculum area to be measured in terms of the influence of digital technologies on children's numeracy learning (see Section 3.3.3.2). The next section will outline how the EYLF covers the learning area of numeracy.

2.5.2 Numeracy and the EYLF

The EYLF states that numeracy 'broadly includes understandings about numbers, patterns, measurement, spatial awareness and data as well as mathematical thinking, reasoning and counting' (DEEWR, 2009, p. 46), consistent with other definitions of numeracy (Bobis,

Mulliga & Lowrie, 2004). Throughout the EYLF one can find numeracy embedded within every learning outcome; an example can be found in learning outcome 4, which details that 'children develop a range of skills and processes such as problem solving, enquiry, experimentation, hypothesising, researching and investigating' (DEEWR, 2009, p. 37). The next section will detail the development of numeracy in the early years.

2.6 Pedagogical Content Knowledge - Numeracy Pedagogies

Within the TPACK model, pedagogical content knowledge refers to 'the ways of presenting and formulating the subject that make it comprehensible to others' (Chai et al. 2011, p. 1185). This section will address some of the factors that influence children's numeracy growth and the appropriate pedagogies to achieve numeracy learning outcomes. To build on children's early numeracy potential the Australian Association of Mathematics Teachers (AAMT) and Early Childhood Australia (ECA) recommend 'appropriate actions to ensure that all young children have access to powerful [numeracy] ideas and learning in their early years, and to learning that nurtures success and positive dispositions' (AAMT & ECA, 2006, p. 1). They recommend that educators of young children 'use accepted approaches to early childhood education such as play, emergent, child-centred and child-initiated curriculum to assist young children's development of [numeracy] ideas' (2006, p.3). Furthermore, they recommend that children be given 'appropriate materials, space, time and other resources to encourage children to engage in their mathematical learning' (AAMT & ECA, 2006, p. 3). Varol and Farran (2006) add that factors such as the learning environment, numeracy tools, classroom discourse, numeracy tasks and assessment are all factors that will influence young children's ability to achieve numeracy outcomes. The next sections will focus on two factors described by Varol and Farran (2006) that are the most pertinent to the present study, which include: (a) attitudes towards numeracy within early childhood and (b) the use of numeracy tools.

Educators of young children will determine if children are exposed to numeracy within early childhood learning environments. Therefore, attitudes early childhood educators have towards numeracy and their corresponding ability to teach numeracy impacts on the quantity and quality of numeracy in which children will be exposed. Attitudes have been addressed as linking affective domains to reactions; hence attitudes influence behaviour (Lee, 2005). A study of what pre-kindergarten teachers believed to be appropriate numeracy showed that

teachers believed that they 'needed to provide [numeracy] education, especially in simple arithmetic, albeit in a fun manner, without triggering stress or anxiety' (Lee & Ginsburg, 2007, p. 2). Educators' attitudes towards numeracy and numeracy teaching are strongly associated, and a reported self-confidence in numeracy has been associated with an enjoyment of teaching numeracy (Lee, 2005). Research by Sarama and DiBiase (2004) illustrates that early childhood educators often feel uncomfortable with numeracy and have a narrow view of content and little knowledge of the development of these ideas. Additionally, they showed that most parents also have a limited view of numeracy appropriate for young children. Moreover, due to the relative lack of confidence of many early childhood educators and parents in their knowledge of numeracy and its pedagogy, there often is a resultant pedagogical practice of 'teaching the way you were taught', hence diminishing opportunities for new pedagogical opportunities (Perry, Young-Loveridge, Dockett & Doig, 2008). This includes the concern that children will not get exposure to new numeracy tools that may assist learning.

In regards to the use of numerical tools within early childhood, prominent figures such as Montessori, Plato, Pestalozzi, Froebel, Owen, and Dewey all advocate that children's exposure to numeracy should be done through objects (Varol & Farran, 2006). Research indicates that the effective teaching of numeracy incorporates the use of concrete materials, which leads to engagement and fun for the learner (Uttal, Scudder & Deloache, 1997). Clements and Sarama (2005a; 2005b) strengthen this argument and state that materials such as water, sand and play dough offer many rich opportunities for exploring early childhood numeracy. In the same articles, Clements and Sarama (2005a; 2005b) also explain that computers are now a part of everyday life and should be utilised as a tool to enhance numeracy learning. The use of appropriate materials and numeracy tools to assist in the development of children's numeracy is of particular relevance to the present study. This is because it constitutes the use of digital technologies to meet curricula outcomes. The following section will address and outline what tools are used within children's digital technology use.

2.7 Technological Knowledge

Within the TPACK model, technical knowledge is 'knowledge of how to operate computers and relevant software' (Chai et al., 2011, p. 1185). This section will analyse digital technologies and explore their impact on the field of early childhood. According to the Victorian Department of Education and Training (DET, 2015) digital technologies are:

> *electronic tools, systems, devices and resources that generate, store or process data. These include social media, online games and applications, multimedia, productivity applications, cloud computing, interoperable systems and mobile devices*.

Palaiologou (2014, p. 3) further explains that the term digital technology 'is used to not only describe desk top computers, but also includes portable mobile devices including smartphones, game consoles, digital cameras, media players, netbooks, in-car satnav and handheld computers'. Therefore the term digital technology refers to both hardware and software within screen-based technological products.

2.7.1 Digital Technology and Young Children

Historically there is debate over the place of digital technology in the lives of young children (Blackwell, Lauricella, Wartella, Robb & Schomburg, 2013; Daugherty, Dossani, Johnson & Oguz, 2014; Zaranis, Kalogiannakis & Papadakis, 2013). The developmental capacities of children within the early years, for example children's inability to independently use digital technology and the one-way communication of television and video, have influenced the way in which digital technologies have been viewed by the early childhood community (Tootell, Plumb, Hadfield & Dawson, 2013). Another reason for the limited use of digital technologies within early childhood settings is they are thought to belong to more formal educational settings (schools) and not fitting within early childhood play-based settings (i.e. distinguished as work, rather than play) (Hedberg & McNamara, 2002; Parette, Quesenberry & Blum, 2010).

Historically (late 1930s-1960s), digital technology was used within the media of films and television and used only in higher education environments (Hedberg & McNamara, 2002). During the 1970s-80s, digital technology in the form of videos became popular within primary school environments; however there was still minimal embracement from educators (Hedberg & McNamara, 2002). During the mid-1980s educational institutions were

beginning to acquire and integrate computers within high school settings, as much to do with the perceived status of being a 'good school' possessing these new educational tools and giving students the ability to practise their typing skills as much as they impact learning (Hedberg & McNamara, 2002; Keane, 2014). The advent of the Internet in the mid-1990s impacted the potential learning opportunities provided by computer and web-based programs for educational purposes. This development began to impact and reflect the manner in which digital technology is used today (Chambers, 2014; Hedberg & McNamara, 2002). Moving into the 2000s and beyond there is now a great deal of research regarding the strengths and limitations offered by digital technology for teaching purposes (Tatnall & Davey, 2014).

The above literature indicates that digital technology has been co-opted into teaching and learning for a long period of time, and many studies were conducted around using them effectively in educational environments, so that their negative potential is averted and their positive potential is boosted. Most research focused only on the school or university education systems, with limited study undertaken about the use of digital technologies within early childhood education environments such as home, childcare or kindergarten; thus little is known of the impact of digital technology on this younger age group. Part of the reason that there are limited studies on the use of digital technology in early childhood settings is that it is not recommended that children under the age of three use digital technology. Rather, that children younger than three should learn through their bodies – their eyes, ears, mouths, hands and legs – and that the developmental skills these children are learning to master are crawling, walking, talking and making friends (Haugland, 2000). Furthermore, a pre-eminent authority in our understanding of children's health, the American Academy of Pediatrics [AAP] (2011) recommends that children under the age of two have no screen time at all. However, the emergence of new digital technologies utilising gestural interfaces have impacted young children's ability to effectively use and consequently learn from digital technology (Plowman & McPake, 2013). Coupled with the NQF and the EYLF, early childhood governing bodies such as ACECQA are recommending that early childhood educators incorporate digital technology into their pedagogical practices.

2.7.2 Digital Technology in the Lives of Young Children Today

Digital technology is in the lives of children and families, both in terms of learning and enjoyment. It continues to grow and change and it is difficult to predict how digital

technology will expand and alter over time (Bower, 2012, 2013; Lee, 2015; National Association for the Education of Young Children [NAEYC] & Fred Rogers Centre, 2012; Parette et al., 2010; Rosen & Jaruszewicz, 2009; Zaranis et al., 2013). Federal Government initiatives such as the *National Innovation and Science Agenda* highlights that Australian should be "embracing the digital age" and that by investing resources into children's digital skills will ensure that the 'next generation of students have the skills needed for the workforce of the future…ensuring Australia's future prosperity and competitiveness on the international stage' (Commonwealth of Australia, 2016, para. 1).

Donahoo (2014) argues that children observe adults engaging with screens for more than eight hours a day, thus sending the message to children that screens are important and a part of their future. It is reported that children spend an average of seven hours a day using screen media (Epstein, 2015). In a case study of 50 three to four year olds from the UK, Plowman and McPake (2013) reported that children accessed screens daily and that all children watched television and DVDs and the majority already had access to cell phones, gaming consoles, MP3 players, desktop, notebook and tablet computers for both work and pleasure, as well as technological toys such as interactive pets. Lee (2015, p.947) supports this, stating that digital technologies are a dominant play activity for young children, as they engage with such technologies as 'mp3 players, iPods, iPads, game Apps, and television'. From an Australian perspective, Yelland (2011, p. 6) confirms that children come to preschool settings with a high level of interest in technological products such as computers, digital cameras, MP3 players, mobile phones and other hand-held devices. And so it is fair to assume that children have access to, and are using, a wide array of digital technology within their homes. A case study by Gronn, Scott, Edwards and Henderson (2013, p. 450) indicated that television was still the most commonly accessed technological product within home settings, despite the increased availability of technological products.

Upon coming to educational settings, children are bringing with them a range of experiences and aptitudes to digital technology; and according to Mercer (2014) to keep up with changing approaches to education, there has been a growing interest in the purchasing of technological products for use within early childhood settings. In a US study by Ntuli and Kyei-Blankson (2012) it was reported that 98% of early childhood teachers surveyed reported having computers in their classroom, with 78% of those using the computer three or more times a

week, hence a high concentration of availability and use. Blackwell et al. (2013) reported in their US study, involving 1329 early childhood educators, that 78.7% of children in centre-based care had access to TV/DVDs, 77.7% to computers, 90.5% to digital cameras, 19.5% to iPod/MP3 players, 12.5 % to iPod touch, 14.7% to E-readers, and 22.4% to tablet computers. However Blackwell et al. (2013) also suggests that whilst there is indeed increased access to digital technology devices within the past few years, the actual effective use of those resources remains infrequent.

In the past few years there has been a proliferation of new digital technologies into the field of education. Potentially the best known and most popular of these are Apple i-Devices (Falloon, 2013; Melhuish & Falloon, 2010; Siegle, 2013). The current study used an Apple iPad. A number of factors led to this decision, these include the nature of the tablet interface for early childhood learners and the current popularity of tablet computers within Australia and the world. According to Kucirkova et al. (2014), since their release in 2010, iPads and associated Apps have become popular worldwide for a variety of users, including preschool children. Highfield (2014) agrees, stating that mobile and tablet technologies are part of children's lives. With Chaudron et al. indicating in their study of over 70 families that tablet devices are children's favourite devices (2015). A tablet computer is a gesture-based mobile computer which allows the user to manipulate software via physical interactions (Anderson et al., 2004). Within Australia there are a variety of tablets available for personal and technical use. Consumer studies show that Apple's iPad is the most commonly owned tablet computer within Australia (Colley, 2010; Kennedy & Nadin, 2014; Tootell et al., 2013). In relation to fine motor skills, on its website Apple Inc. (2011) explains that the iPad 'features a large, high-precision, touch-sensitive display that requires no physical force, just simple contact with its surface'. Therefore, in relation to the aforementioned (Section 2.3.3.2) developing fine motor skills of children within the early childhood age range, the use of gestural interface devices is an appropriate choice for the current study and links appropriately with the theory of embodied cognition (Section 2.3.3.4).

Within the scope of human abilities, gestural interaction using digital technology is based on the theory of embodiment, that cognition is affected by our interaction with the environment. Embodied interaction using gestural interfaces involves more of our senses than traditional (mouse-based) interfaces, and includes touch and physical movement, which are thought to

retain the knowledge that is required. Research by Chan and Black (2006) found that immediate sensorimotor feedback received through direct manipulation of animation through the hands allowed for increased learning as compared to passive animation conditions. Furthermore, Saffer (2008) suggests that human beings are physical creatures and we like to interact directly with objects. Interactive gestures allow for this form of learning, hence a greater likelihood of meaningful learning experiences. Therefore, gestural interfaces such as the iPad provide a hands-on experience and support cognition as explained within embodiment.

There is a growing body of research on the nature of spontaneous gestures and their effect on communication, working memory, learning, mental modelling and reflection of thought (Lindgren & Johnson-Glenberg, 2013; Özçalışkan, Gentner & Goldin-Meadow, 2014; Segal, 2011; Taylor, 2014). Research indicates that gestures augment working memory and provide pathways for both memory and solution enactment (Goldin-Meadow, Nusbaum, Kelly & Wagner, 2001; Kessell & Tversky, 2011; Taylor, 2014). Gestures can help people imagine mental operations and perform mental transformations (Chu & Kita, 2012). Moreover, gestures reveal information about children's developmental stage and could support learning. For example, research by Goldin-Meadow (2009) explains that gestures play a role in changing children's knowledge, as children can explain things using gestures that they may not be able to do verbally. This point is elaborated within research by Goldin-Meadow, et al. (2012, p. 876) that clearly shows that for young children's learning 'doing gestures promote learning better than seeing gestures, as long as the gesture conveys information that could help solve the task'.

Therefore, gestures reveal mental representations and spontaneous gestures affect thought. It could be argued that choosing well-designed gestures (for a gestural interface) could affect the mental operations of an individual and subsequent performance. Hostetter and Alibali's (2008) theory of Gestures as Simulated Actions (GSA) suggests in-depth that gestures emerge from perceptual and motor simulations that underlie embodied language and mental imagery and provide a framework to suggest how gestures may arise from embodied cognitive systems. If gestures are simulated actions, it is then essential that proposed educational tools affectively simulate the mental imagery to the spatial representation of the device. Hence, a further component of the proposed study is not only to analyse whether or not digitally

technology is educationally appropriate, but whether using a gestural interface device promotes learning. As indicated by Pellicano, Thill, Ziemke and Binkofski (2011) when considering the integration of new tools into a learning environment, researchers need to consider how the human mind can incorporate new knowledge (plasticity) and how the sensory-motor response of the participants using those tools adds to or builds upon pre-existing schemes and potentially new neural pathways. Therefore, the design of the software used with gestural interface devices must also be considered in terms of how the software best highlights user capacity. The next section will outline Apps used with iPads and the potential impact of their use for young children.

2.7.3 Apps (Software)

Software is essentially a collection of computer programs and related data that tell the computer what to do. There are three types of basic software for children, these being: (1) enabling software (specialist word processors, children's Internet browsers and children's art packages), (2) entertainment software (games and media products), and (3) educational software (linked to a published curriculum or designed to support the mastery or assessment of a specific skill) (Sim, MacFarlane & Read, 2006, p. 236). Within the present study there was an emphasis on educational software via interactive media. The concept of interactive media becomes important in terms of being developmentally appropriate for use with young children. Interactive media for the purposes of this study 'refers to digital and analogue materials, including software programs, applications (Apps), broadcast and streaming media, some children's television programming, e-books, the Internet, and other forms of content designed to facilitate active and creative use by young children' (NAEYC & Fred Rogers Centre, 2012, p. 1).

The current study will use an Apple iPad; therefore there will be a focus on software via the Apps section of Apple's iTunes store. An 'App' is an abbreviation for application – a piece of software that can run on the Internet, on a computer, or on a hand-held device (Karch, 2015). The App store has specific recommendation for why Apps are rejected from being available on the Apple store. Issues which impact directly on user experiences include crashes and bugs, substandard user interface, broken links, advertisements, inaccurate descriptions and not enough lasting value (Apple Inc., 2016). According to the Apple website there are currently 75,000 educational Apps designed specifically for iPads (Apple Inc., 2015).Within

the iTunes store, there is a large range of free and purchased Apps specifically designed for children aged 3-4 years, commonly referred to as Apps for preschool education. In a report by Shuler (2012, p. 3) regarding an analysis of the educational category of the Apples App store, two pertinent features stood out in relation to the present study: (1) more than 80% of the top selling paid Apps in the education category of iTunes target children, with 72% of the Apps targeting preschool or elementary aged children, and (2) general early learning Apps are the most popular (47%) within the age category of toddler/preschool, followed by numeracy (13%). Kucirkova et al. (2014) state that Apps created and downloaded for preschool and toddler aged children are very popular. Thus, the current study will use Apple's iPad and associated Apps as the medium through which educational games will be used with children aged 3-4 years. With such a wide variety of gaming options available, it is important when integrating digital technology into early childhood settings that the potential impact and quality of Apps/games on the user is understood (Bower, 2012; 2013; Mercer, 2014; O'Hare, 2014).

There are a number of rating websites freely available to early childhood stakeholders to assist in rating Apps, however care must be taken to avoid potential misinformation and financial bias (Stoyanov, Hides, Kavanagh, Zelenko & Mani, 2015). Websites such as the American *Common Sense Media* comprehensively assist in early childhood stakeholders to rate and evaluate interactive media in terms of both appropriateness and educational value. Whilst in Australia, sites such as the *Australian Council on Children and the Media* assist in understanding age appropriateness of interactive media. When considering the potential impact of digital games on children, Lieberman, Fisk and Biely (2009, pp. 300-301) explain that gaming often fits within three basic domains: (1) well designed games, (2) poorly designed games, or (3) very poorly designed games. A well-designed game can provide children with 'interactive experiences that can foster young children's learning, skill building, and healthy development'. Conversely, if games are poorly designed they 'can be time-wasting sedentary activities that contribute little to children's learning, skill building, or healthy development and instead are associated with obesity and poor cardio-vascular fitness'. In extreme circumstances, very poorly designed games can impact children as they 'can do significant harm, such as teaching, modelling, and rewarding aggressive or anti-social behaviour, instilling fear and anxiety, portraying and condoning ethnic and gender

stereotypes, glorifying poor health habits and teaching other unwanted lessons' (Lieberman et al., 2009, pp. 300-301).

Expanding on the potential issues with poorly or very poorly designed games, More and Travers (2012, p. 17) explain that whilst early childhood educators may assume that educational Apps are developmentally appropriate, the reality is that many Apps are 'lacking essential design, instruction, content, accessibility, and individualisation features'. However, whilst many games designed for young children may not be appropriately designed, Lieberman et al. (2009, p. 308) also list a range of potential benefits for children when engaged within well-designed games. The list includes that learning and cognitive skills can be developed during well-designed games and that there is the potential for high levels of social interaction within games, and healthy behaviours can be promoted through in-game content. Therefore, it is imperative for effective use of digital technology in early childhood settings that stakeholders are aware of what quality educational Apps are and how to identify them (Marsh et al., 2015; Mercer, 2014).

Varol and Colburn (2007, p. 163) describe four factors outlined by the National Association for the Education of Young Children (NAEYC) that creators of educational software for children should take into account in the design process. These factors include software that is suitable for the learners' age level so that the children can achieve goals in a challenging manner, or children may get bored or frustrated. Secondly, whilst designers cannot know individual children's interests, strengths and needs, they should evaluate a broad range of these alongside gender-related factors and use that information for greater individualisation. Thirdly, knowledge of cultural and ethnic differences will allow designers to understand the context in which children live to make new concepts and tasks meaningful, relevant and respectful of the children. Haugland (2000) also describes factors that should influence educational software development, and suggests that software should be open-ended, child-driven, and build critical thinking skills whilst avoiding drill and practice style activities. To assist educators in making choices about which software to choose, The Haugland Developmental Software Scale (Haugland & Wright, 1997) provides a list of criteria and related scale that rates software for its appropriateness. For young children, these include that software: (a) is age appropriate and has child in control, (b) has clear instructions, (c) has expanding complexity, (d) has independence, (e) is non-violent, (f) is process orientated, (g)

has a real-world model, (h) has technical features, (i) has transformations, (j) has multiple languages, (k) is universal focussed, (l) has mixed gender and role equity, (m) has people of diverse cultures, (n) has differing ages and abilities and (o) has diverse family styles.

Falloon (2013) claims that Apps can be developed into thoughtful and engaging learning tools via iPad devices. In his research, Falloon (2013, p. 519) describes six features for effective App design based on a case study of five year old children's App play. The six features include: (1) communicating learning objectives in ways young students can access and understand, (2) providing smooth and distraction-free pathways towards achieving goals, (3) involving accessible and understandable instructions and teaching elements, (4) incorporating formative, corrective feedback, (5) combining an appropriate blend of game, practice and learning components, and (6) providing interaction parameters matched to the learning characteristics of the target student group. Within his study, Falloon (2013) indicated that price was not always an obstacle to meeting the features required for effective and engaging Apps, with many paid Apps not being considered appropriate in terms of the features outlined above. However, Falloon (2013) also indicated that games that understood or claimed to understand effective teaching pedagogies did indeed meet the expected features of App design. Whilst a small-scale project, Falloon's research gives clear insights into that thinking that must be given when educators adapt digital technology with children.

Hirsh-Pasek et al. give further insight into the essential component for App design as they describe four pillars upon which Apps should be developed. Firstly, that Apps should involve 'active learning'; developmentally appropriate cognitive tasks within Apps challenges children's thinking, therefore rather than cursory swiping at random or sensory stimuli, Apps should challenge children's thinking (2015, p. 8). Secondly, there should be 'engagement in the learning process'; focussed attention maximises learning opportunities, therefore Apps should minimise erroneous content and focus on the learning at hand (2015, p. 11). Thirdly, Apps should contain 'meaningful learning'; children construct knowledge, Apps should relate to meaningful experiences that build upon children's interests (2015, p. 13). Finally, Pasek at al. conclude that Apps must include 'social interaction'; be it interaction via the screen through gestures or the encouragement of social interaction with the children's peers in gameplay, children learn best when learning in collaboration (2015, p. 16).

Whilst many authors and models describe the tenets for appropriate software selection for young children, such as the Haugland Developmental Software Scale (Haugland & Wright, 1997), the overall selection of software when using new digital technologies such as gestural interfaces must also encompass a comprehension of how the new digital technology can most effectively be used to maximise potential human computer interactions (HCI) (Wigdor & Wixon, 2011). In their book *Brave NUI World*, Wigdor and Wixon (2011) describe what they believe to be the key elements to designing software appropriate for gestural interfaces. These included contextual environments, spatial design, seamlessness, scaffolding, no touch left behind and the autonomy of a gesture. Therefore, App rating scales need to consider both software content as well as the operating interface. Such rating tools include the Preschool App Evaluation Guide (More & Travers, 2013), Pre-MEGa (Shoukry, Sturm & Galal-Edeen, 2015) and the App rating scale used in the current study, the Gestural Interface Rating Scale (GIARS) (see Appendix K). There is a range of gestures associated with gestural interface devices it is therefore important that children can perform these gestures to maximise engagement and learning. Research conducted by Stone, Aziz, Sin, Batmaz and Chung (2014) measured the gestures that children two to four years of age could manage whilst using iPads. The gestures measured were: tap, drag/slide, free rotate, drag and drop, pinch, spread and flick. The results indicated that 100% of 4 year olds could perform all of the gestures, as the children's age decreased the percentages of children's ability to perform all of the tasks also decreased. In an analysis of 100 commercial Apps aimed at two to three year old children highlighted that 99% of Apps used tap gestures and 56% used on tap and drag gestures as their only supported operations (Nacher, Jaen, Navarro, Catala & Gonzalez, 2015). Therefore, App designers are considering the developmental capacities of children within the early year in terms of operational control. However, Nacher et al. (2015) suggest that even young children are capable of more complicated gestural controls than most Apps allow. It is therefore important when choosing educational software for children to consider both the content of software and how the software utilises the interface it is designed for; thereby giving educationally appropriate information and utilising the mode of delivery to maximise children's engagement and learning potential (Kucirkova et al., 2014; Yelland, Gilbert & Turner, 2014).

2.7.4 Digital Play

As discussed in Section 2.7.1, there is continual debate over the appropriateness of digital technology for young children. An element of the debate is if children's use of digital technology constitutes play, therefore an approved pedagogical method for young children's learning? According to Gonzalez-Mena (2013) play involves: (1) active engagement, (2) intrinsic motivation, (3) attention to the means rather than the ends, (4) nonliteral behaviour, and (5) freedom from external rules. Warburton and Highfield (2012) suggest that children's use of digital technologies may only meet one or two criteria when analysing specific definitions of play. However, within the EYLF, play-based learning is defined as a 'context for learning through which children organise and make sense of their worlds, as they engage actively with people, objects and representations' (DEEWR, 2009, p. 6). Palaiologue (2014, p. 1) argues that children under five are 'engaging with digital technologies in playing and learning at home and this cannot be overlooked by early years education'; thereby a need to reconceptualise young children's learning. To analyse whether children's use of digital technology is play-based learning requires an understanding of the elements that constitute digital technologies' integration within early childhood settings. In this study, digital play is defined when there is an assimilation of early childhood contexts, play-based learning and digital technologies that merge together to influence children's enjoyment and engagement within learning to facilitate curricula outcomes. Figure 2.3 highlights the Digital Play model, which is based on the component elements of the TPACK framework outlined in Section 2.2, involving context, technology, content and pedagogical knowledge to comprehend the integration of digital technologies within early childhood to form digital play.

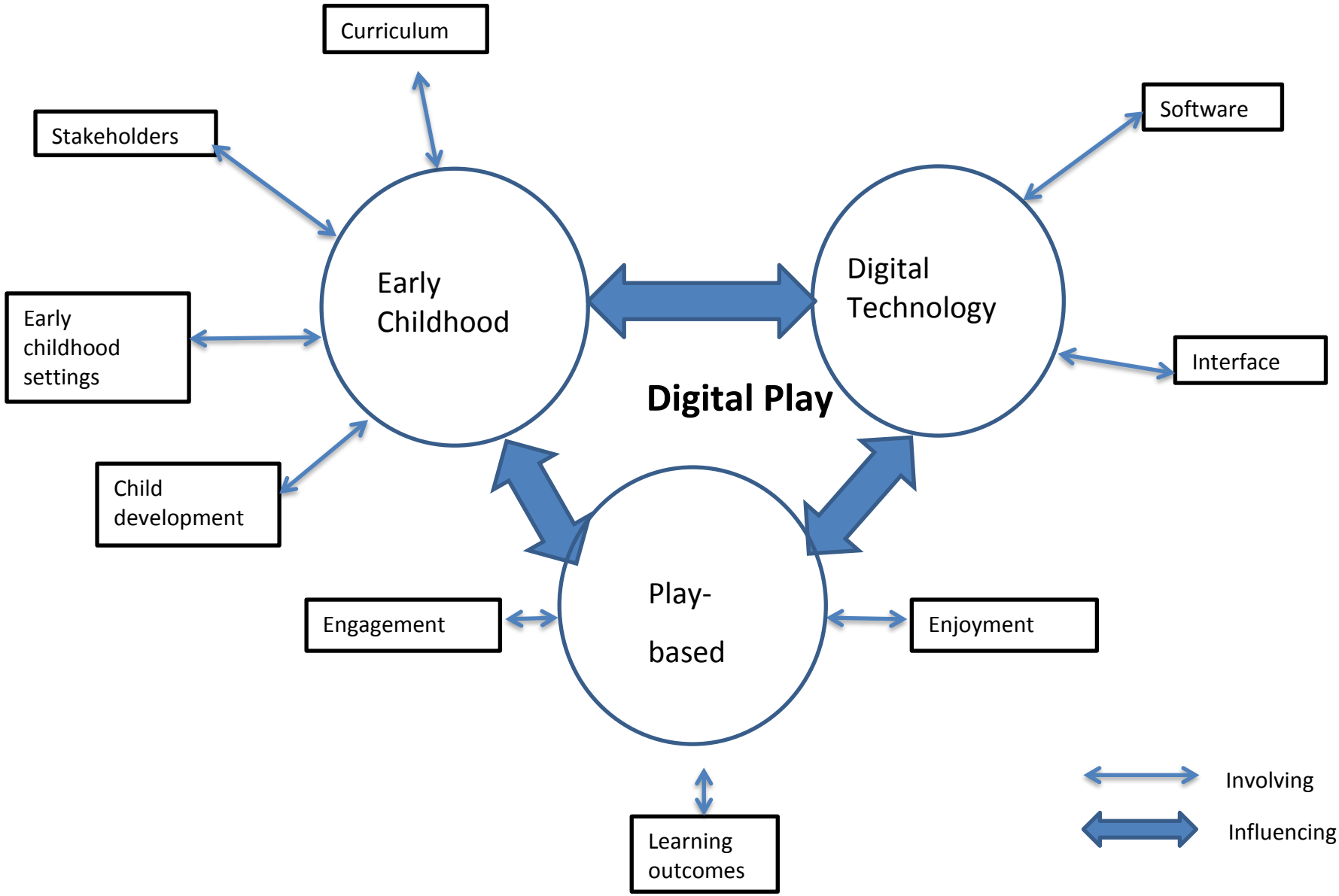

Figure 2.3. Digital Play model.

An ideological shift is required by the field of early childhood in order for the successful integration of digital technologies to occur and digital play to become a reality. The premise that digital technologies are their own form of pedagogy within the early years is a fundamental idea shift for early childhood; ideas change and evolve (Laudan, 1977). The field of early childhood appears to be at a tipping point at which fundamental concepts regarding technology need to be reconsidered; such tipping points require change to predominant thinking (Ledford, 2008). To conceptualise such a change requires individuals and the collective to consider the idea 'by looking at the shifting position of an idea within a broader conceptual network which is undergoing continuous modification' (Laudan, 1977, p. 181). The theoretical Digital Play model detailed in Figure 2.3 proposes a model of digital play that must consider three domains to merge together to re-analyse the role of digital technology within early childhood education, these being: early childhood settings, play-based learning and digital technologies themselves, all existing within the evolution of practice over time. Therefore, in order for the early childhood community to consider digital technologies as their own pedagogical approach to learning rather than a 'tool' to assist learning, it will require a theoretical as well as a philosophical shift in fundamental thinking. This will require a questioning of the historical and fundamental components of play.

Currently, digital technologies sit within Australian early childhood policy documents and frameworks as adjuncts to children's learning, rather than as specific forms of play. By this, learning outcomes can be achieved through using digital technologies. For example, within the EYLF for Outcome 4, educators need to 'introduce appropriate tools, technologies and media and provide the skills, knowledge and techniques to enhance children's learning' (DEEWR, 2009, p. 33). Hence, digital technologies are seen as tools to support learning rather than a specific form of learning. Thereby, digital technologies are seen as separate to play, which Edwards (2013a) explains is a common sticking point within international early childhood curricula documents. In addition, texts on children's play, such as Fleer's (2013) *Play in the Early Years* describe the relationship of digital technologies to play as one of supporting children's play, rather than being a distinct form of play. Edwards (2013a, 2013b) argues that digital technologies need to be considered not as individual tools, but rather considered within the context in which children and society view them and that current and traditional forms of play are intersecting to alter the landscape of play definitions moving

forward. Digital technology is increasingly being integrated into education to prepare students for future workplaces as well as enhancing learning (Daugherty et al., 2014). Children observe adults using digital technologies throughout their day-to-day life (Donahoo, 2014) and they are consumers of the images, audio and textual information that they receive via digital technologies (Edwards, 2013a). Therefore the contexts in which children view digital technologies reflect a modern construct of how they make meaning of their world, one of the primary functions of play-based learning (DEEWR, 2009; Fleer, 2013). Thus, the use of digital technologies needs to be considered against the tenets of play-based learning, in that children are constructing knowledge based on information consumed via technologies.

However, mere consumption of the information gained from digital technologies cannot in its own right be considered as play or play-based learning. Rather, the context of change highlights that digital technologies are now more accessible and useable by young children, maximising human computer interactions (Wigdor & Wixon, 2011) via gestural interfaces. Therefore digital technologies, which employed interfaces that were difficult or impractical for use, now fit within the developmental capacities of young children, creating an engaging and enjoyable experience that models play-based activities and learning. Again, the changing context of interface design allows for a re-imagining of the potential of digital technologies to fit within children's capabilities and play. Whilst the changing nature of interfaces enhance children's experiences with digital technologies, Warburton and Highfield (2012) warn that associated instructive software is often lacking in the specific design structures that are associated with play; rather promoting rigid skills based instruction which 'rarely promote higher-order thinking skills such as reasoning, evaluating or creating' (Highfield, 2014, p.37), hence opposing Gonzalez-Mena's (2013) definition that play must be attention to the means rather than the ends and have freedom from external rules. Phase 2 of the current study will determine the role of the 50 most popular numeracy Apps for young children, hence reviewing Highfields's (2014) claim that the majority of Apps are instructive in nature. The role of Apps for the development of early childhood numeracy outcomes is discussed in Section 2.10.1 and will expand on the nature of instructive-styled Apps for children's learning.

Whilst digital technology has been embedded within society (Palaiologou, 2014) and encouraged within early childhood curricula documents in Australia, this does not however

govern that early childhood settings will be accepting and consequently use digital technologies. For children's use of digital technologies to move into the categorisation of digital play there has to be an acceptance by the early childhood community towards digital technologies as a play model for young children. In discussing digital technologies and their fit within early years pedagogy, Palaiologou (2014, p. 15) suggests 'the remaining question is to investigate to what extent early years education is ready to accept the "digital child" of the twenty-first century'. It is pertinent at this stage of the review to examine the attitudes people invested within early childhood education have in relation to the integration of digital technology. Plowman and McPake (2013) discuss that whilst certain early childhood stakeholders will point out that digital technology is an important part of children's futures, others will state that children should not be using digital technology, but should rather be outside 'playing' or reading books. It is important to note that attitudes influence behaviours and that strength of attitudes will have direct implications for affecting behaviour (McLeod, 2009). Therefore, it is important to analyse the attitudes of early childhood stakeholders to understand why digital technology is, or is not, being integrated into early childhood settings and if there is potential for digital play to become pedagogical vernacular within the early years.

2.8 Attitudes and Barriers towards Adopting Digital Technology in Early Childhood

Barriers towards the acceptance of digital technologies within early childhood services can be broken into two primary sectors: (1) first-order barriers, which include extrinsic barriers such as 'lack of time, training, professional development, access to sufficient hardware and software, and support' and (2) second-order barriers, which are personal limitations including 'teaching beliefs, perceived value of technology for education, and comfort with technology' (Blackwell et al., 2013, p. 311). Survey data from 1,234 early childhood educators in the United States indicated that attitude had the strongest direct effect on technology use, followed by support, confidence, technology policy and teaching experience (Blackwell, Lauricella & Wartella, 2014, p. 87). Second-order barriers are closely linked to attitudes held by stakeholders in relation to the value of digital technologies within early childhood environments, and influence behaviour and practice. In the aforementioned Blackwell et al. (2013) study, first-order barriers influenced educators' access to emergent technologies;

however it was the second-order personal beliefs that influenced the actual use of technology within the early year's educational settings. An educator may have first-order barriers broken down by access to digital technological devices, however their actual effective use of technology will be directly related to the attitudes they hold towards the value of digital technology for young children. In Lindahl and Flokesson's (2012) study with 31 preschool educators relating to their attitudes towards the adoption of technology within their teaching practice, they found that opinions were divided into either a positive overall embracement or a complete rejection due to perceived changes to preferred pedagogical approaches.

In light of these findings, a component of the current study is designed to identify the attitudes held by early childhood educators in relation to the acceptance of digital technology into early childhood settings. Plowman and McPake (2013) suggest that early childhood stakeholders have many questions about the use of digital technology within early childhood education, all of which influence their attitudes to determining if digital technologies can become digital play. In regards to the influences from the attitudes towards practices, educators' and parents' attitudes can be considered to be individual conceptions about different ways of teaching or conceptions about the way in which children learn (Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur & Sendurur, 2012; Kerckaert, Vaderline & van Braak, 2015; Pynoo & van Braak, 2014). Personal attitudes represent psychologically understanding, premises or propositions felt to be true in the physical and social areas (van der Linden, Bakx, Ros, Beijaard & van den Bergh, 2015). In addition, attitudes can consist of a mixture of opinions, values and expectations in a structured way because those attitudes have already been shaped by prior personal experience (Varol, 2013; Kregor, Breslin & Fountain, 2012). Thus, attitudes are relatively stable (Ertmer, et al., 2012). Accordingly, attitudes are reflective in teaching approaches or parenthood (Schuh, 2004). This implies that it is important to consider the mediating impact of attitudes in the influence process of educational practices and it is particularly true when educational innovations, such as the implementation of digital technologies, are involved in young children's education environments (Bryderup & Kowalski, 2002; Kerckaert et al., 2015; Shapka & Ferrari, 2003; Tearle, 2003; van Braak, Tondeur & Valcke, 2004; van der Linden et al., 2015). Stakeholders enter with their personal theories or attitudes as well as their personal interpretation of the instructional situation (Confait, 2015; Uhlenbeck, Verloop & Beijaard, 2002). In this present study, educators' and

parents' attitudes towards the use of digital technology will be investigated to test the above statement, given that they are important people in the concrete implementation of an innovation process (Albirini, 2006) within an early childhood education setting.

The role of digital technologies in the current educational environment is becoming more prevalent and accepted in terms of being a mainstream pedagogical tool. In their book, *Born digital: Understanding the first generation of digital natives*, Palfrey and Gasser (2008) describe that we are currently undergoing the most rapid technological transformation in terms of information. Children are being born into a digital age whereby the ways they gather and interpret information will be different to those of their parents and educators (Geer & Sweeney, 2012; NAEYC & Fred Rogers Centre, 2012). Lee (2015) argues that the use of digital technologies has altered the daily lives of children in the way they communicate and learn. Yelland (2011) maintains that children are not passive within the process of consuming media and will self-select media content, and that new digital technologies can play a large role in effective consumption. In order to effectively educate the 'digital native' child (born into the current world immersed in technology), parents and educators who are 'digital immigrants' (adapted to the new technological world) need to address their own attitudes towards digital technology and how the technological advancements fit within their comprehension of children's learning and their concept of early childhood education (Palfrey & Gasser, 2008; Plowman & McPake, 2013). This will in turn lead to a potential acceptance of children's play with digital technologies to become the accepted pedagogical practice of digital play.

The term 'digital citizenship' takes form within the current digital technologically expanded times in which children are growing up and it refers to the:

> …*need for adults and children to be responsible digital citizens through an understanding of the use, abuse, and misuse of technology as well as the norms of appropriate, responsible, and ethical behaviours related to online rights, roles, identity, safety, security, and communication* (NAEYC & Fred Rogers Centre, 2012, p. 10).

Therefore, it becomes incumbent on educators within the current early years educational environments to prepare their learners for the appropriate use of digital technology (Donohue,

2015; Rosen & Jaruszewicz, 2009). Furthermore, Plowman and McPake (2013) indicate that whilst children are 'digital natives' in terms of the time period in which they were born, the reality is that they are learning their skills and attitudes towards technology from the 'digital immigrants', be that their parents or educators. The question however remains – at what age and in which settings should this guidance to become digital citizens take place? Within the new digital age, parents and early childhood educators have access to, and are allowing children to be exposed to, a wider variety of digital technological alternatives to enhance and build on children's experiences and develop their own pedagogical practices (Clark, 2011; Colker, 2011). A study by Lauricella, Wartella and Rideout (2015) involving 2300 parents of children birth to age eight, indicated that parents with positive attitudes towards the impact of technology correlated with increased technology use by their children. Growing curricula expectations that digital technologies become a part of mainstream pedagogy, combined with the fall in price of technological products, has led to a proliferation of digital technology alternatives being brought to the attention of children (NAEYC & Fred Rogers Centre, 2012; Sim, et al, 2006). As reported by Gronn et al. (2014) there is a broader range of digital technologies accessed within the home compared to school, including preschool settings. However, dependent on socio-economic background, the exposure might be limited in terms of quality and quantity of digital technological products within the home, with the potential to create a digital divide between those with and those without access to developmentally appropriate technologies (Blackwell et al., 2013; Daugherty et al., 2014; NAEYC & Fred Rogers Centre, 2012). Whilst there are still early childhood services without the presence of digital technologies, there is overall growth within the array of digital technologies being used with children in the early years (Parette el al., 2013). Therefore there is an opportunity for early childhood services to provide children with access to digital technologies that may lessen the potential for a digital divide once children reach compulsory school settings.

Exposure to and engagement with digital technologies has a number of perceived benefits for children, however not all stakeholders are welcoming of the integration of digital technology into early childhood settings (Blackwell et al., 2013; Ficken, 2013). Furthermore, there is an undercurrent that digital technologies are drastically altering the landscape of early childhood to its detriment (Plowman, McPake & Stephen, 2010). Currently there is a dearth of empirical studies relating to the value and impact of emergent digital technologies (such as iPad) in the

early years; in its absence are a number of widespread myths relating to children's use with digital technology (Kucirkova et al., 2014 ; Plowman & McPake, 2013). Therefore, there is a dichotomy of opinion regarding digital technologies within the early years, indicating that attitudes need to be addressed before successful integration can occur or digital play can become a mainstream part of early childhood terminology.

To understand the barriers and attitudes encountered by early childhood educators to the integration of digital technologies into early childhood settings, this chapter will frame these barriers and attitudes within the User Acceptance of Information Technology 2 (UTAUT2) model (see Figure 2.4) (Venkatesh, Thong & Xu, 2012). The UTUAT2 was designed so as to understand the variables as to why information technologies are accepted or not within home/work practices; it is the synthesis of a range of user acceptance models (Venkatesh at al., 2012). The UTUAT2 was re-developed based on the User Acceptance of Information Technology (UTAUT) and incorporated the advent of touch screen technologies. The original UTUAT model relied on four primary constructs to explain why people adopted digital technology; these were performance expectancy, effort expectancy, social influence and facilitating conditions (Venkatesh, Morris, Gordon & Davis, 2003). The UTUAT2 model expanded on these concepts, incorporating three new constructs including hedonic motivation, price value and habit. These constructs are juxtaposed against user's individual differences of age, gender and experience as variables to why technology is integrated or not.

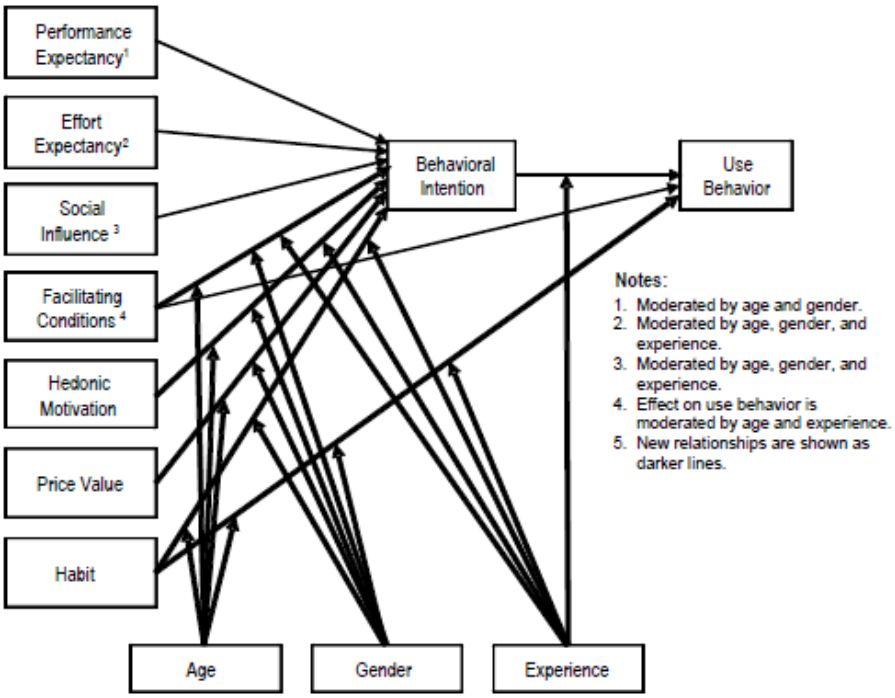

Figure 2.4. The UTAUT2 model (Venkatesh et al., 2012).

The seven primary constructs of UTAUT2 will be explained in relation to the reasons digital technologies are accepted into early childhood or not. The analysis will begin with discussing social influencing factors to digital technology integration into early childhood.

2.8.1 Social Influence

According to Venkatesh et al. (2012, p. 159), social influence 'is the extent to which consumers perceive that important others (e.g. friends, family, co-workers) believe they should use a particular technology', or the way in which they believe others will view them due to their use of digital technology (Venkatesh et al., 2003). Social influences can impact the potential user's belief structure regarding digital technology use, as well as the perceived social status given to the use of digital technology, and fall within the second-order barrier of technology integration (Blackwell et al., 2013). Furthermore, social influence also determines the social pressures given to the integration of digital technology within practice, especially when the pressure comes from those with the ability to reward or punish behaviour. Within mandatory settings, social influences affect how users implement digital technology, whereas within voluntary settings social influences impact perceptions of digital technology and consequent use. Within early childhood settings the use of digital technology is not

mandatory, rather voluntary; therefore perceptions of digital technology are important as they dictate use. Social influence dissipates with time as users form their own judgment based on personal experience (Venkatesh et al., 2003). Venkatesh et al. (2003, p. 453) go on to state that women are particularly sensitive to the opinions of others and that older people are initially more salient to social influences, which decreases with experience.

Digital technologies are becoming a tool commonly associated within both work and home environments. Proponents of digital technology integration will argue that early childhood is a time for children to become familiar with technologies that will become a major part of their working lives (Daugherty et al., 2014). However, others argue that technology changes so rapidly that exposing children to technology that will become redundant, when they could be focused on other foundational early years learning tasks, is counter-productive to development (Plowman & McPake, 2013). According to Plowman and McPake's (2013) study, some children will be keen to engage with digital technology and others less so. However, there is growing consensus that young learners are embracing the use of new technologies such as iPad (Siegle, 2013), and stakeholders in early childhood are seeing these tools being used daily and becoming socially accepted in terms of relevance and functionality (Bower, 2012; NAEYC & Fred Rogers Centre, 2012). In Yurt and Cevher-Kalburan's (2011) study involving 100 early childhood educators, 94.7% agreed that computer usage is appropriate in early childhood education. Bower (2012) and Ficken (2013) suggest that early childhood educators should not only be open to the integration of digital technology within early childhood settings, but also actively advocate for their use due to the possible transformational potential of the tools for pedagogical and curricula benefits in the early years. Plowman and McPake (2013) indicate that early childhood educators regularly have informal chats about children's literacy and numeracy practices within the home. If this is extended to discussing digital technology in children's lives, it would give educators a complete picture of the child's life and how links can be made. Furthermore, appropriate modelling of digital technology use by adults in front of young children empowers adults to learn more about technology as well as strengthening co-viewing and joint participation between the adult and child. This leads to digital citizens developing appropriate, safe, healthy and socially positive digital technology practices (NAEYC & Fred Rogers Centre, 2012; Plowman & McPake, 2013).

Despite the intent to integrate, the concept of integration of digital technology can become problematic when educators read material where the negative impact of digital technology is reported (Bower, 2012). In addition, current governmental regulations have statements that do not reflect the current trends in technological innovations. The current recommendations for TV and computer games stated by the Department of Health [DoH] (2014) include that children under the age of two 'should not spend any time watching television or using other electronic media (DVDs, computers or other electronic games), and that children between the ages of 2-5 'should be limited to less than one hour per day'. These guidelines are linked to some of the health and long-term concerns regarding the overuse of screen media, which includes childhood obesity, sedentary lifestyle diseases, the effects of background television, passive screen use, irregular sleep patterns, postural care, repetitive stress injuries, behavioural problems, attention concerns, limited play time, decreased academic performance, negative impacts of socialisation and poor language development (AAP, 2011, Bower, 2013, Campaign for a Commercial-Free Childhood, 2012; DoH, 2014; Edwards, Skouteris, Rutherford & Cutter-Mackenzie, 2012; Finegan & Austin, 2002; NAEYC & Fred Rogers Centre, 2012; Plowman & McPake, 2013; Plowman & Stephen, 2003; Struppert, Guo & Waniganayake, 2010). According to NAEYC and Fred Rogers Centre (2012, p. 2) a number of public health and child advocacy groups have called for the banning of non-interactive screens within early childhood programs and screen media to not be used for infants and toddlers.

It is not uncommon in contemporary early childhood environments for a non-screen policy to be in place. Such a policy appears to be a method for managing parental concerns for screen use with young children and gives the impression that the service values 'other' forms of learning over digital forms (Digichild, 2014; Donahoo, 2014). Furthermore, advocates for the use of appropriate digital technologies for children, such as Fred Rogers Center for Early Learning and Children's Media, make a clear distinction that digital technology should complement educators' existing pedagogical practices and exposure should be in a very limited capacity for infants and toddlers (NAEYC & Fred Rogers Centre, 2012). The difficulty within these arguments is that research findings remain divided, combined with recommendations of very limited to non-use from health organisations such as the American Academy of Paediatrics (AAP) which causes confusion for early childhood stakeholders in

terms of the appropriateness and value of digital technology (Blackwell et al., 2013; NAEYC & Fred Rogers Centre, 2012). An interesting development of change in the stance that digital technology should be banned for children under 2 emerged when Dr Dimitri Christakis, one of the authors reaffirming the AAP's position on screen time for children, stated 'I believe that judicious use of interactive media is acceptable for children younger than the age of two' (Donahoo, 2014, p. 21). Adding to the confusion regarding the potential risk of screen media for young children is that whilst parents are aware of the reported dangers, they believe it is not a problem for their own children, but that it impacts children from other families. Moreover, researchers appear to be more concerned about the reported dangers than parents themselves (Funk et al., 2009; Plowman & McPake, 2013; Takeuchi, 2011).

Contributing to the confusion, regarding young children's digital technology use is that not all interfaces are created in the same manner (Donahoo, 2014). It is argued that emergent digital technologies, such as gestural interface devices, which respond to children's movements and interactions, can be scaffolded to promote development and learning and should not be put in the same category as non-interactive digital technology (NAEYC & Fred Rogers Centre, 2012). Non-interactive digital technology is described as 'certain television programs, videos, DVDs, and streaming media on a variety of screens' (NAEYC & Fred Rogers Centre, 2012, p. 2). However, Plowman and McPake (2013, p. 30) warn that whilst certain developers claim their Apps to be 'interactive', they are however not taking full-advantage of the touch screen design and the software is often re-hashed versions of games for other non-touch platforms, therefore claiming that 'technological interactivity does not guarantee an educational encounter'. As Bower (2013) and Donahoo (2014) point out, educators should be concerned with the negative implications suggested by media reports in relation to digital technology; however they should be viewed by educators as an opportunity to discuss appropriate use, as well as to research and plan effectively as for any new tool within an educational setting. Planning within early childhood has direct links to quality (DEEWR, 2009), therefore understanding how to plan for the effective use of digital technology is vital for early childhood educators. This includes considering the manner and difficulty associated with use, which will be reviewed in the next section on effort expectancy.

2.8.2 Effort Expectancy

Effort expectancy is defined as the 'degree of ease associated with consumers' use of technology' (Venkatesh et al., 2012, p. 159). Effort expectancy is significant for both mandatory and voluntary use of digital technology. However, as can be expected, the effects of effort expectancy decrease significantly with time as users become more comfortable using the technology, at which time instrument concerns overshadow effort expectancy, deciding 'which digital technologies' to use rather than 'if' to use digital technology (Venkatesh et al., 2003). Furthermore, Venkatesh et al. (2003, p. 450) explain that age and gender play a role within effort expectancy. Older people find processing technological skills harder and 'effort expectancy will be most salient for women, particularly those who are older and with relatively little experience'. For both educators and parents there is the potential to question their own abilities to use technology effectively with children and consequently they may avoid technological use due to their own limited knowledge (Mercer, 2014; Plowman & McPake, 2013). In the case of digital technologies, the effort expectancy of the adult is not the only concern; the effort expectancy of the child is paramount to ease of use within early childhood play settings.

As discussed in Section 2.7.1, previous digital technologies such as the standard computer with mouse and keyboard setup prove very difficult and problematic in terms of ease of use for children, and for setup and maintenance for the educator. Due to fine motor control issues and durability concerns, standard desktop/laptop computers are not seen as early childhood friendly learning tools (Bower, 2012; Kucirkova et al., 2014; Plowman & McPake, 2013). However, with emergent digital technologies such as iPads, using a gestural interface, children are not only enthusiastic towards the use of technology but can operate them easily (Bower, 2012, 2013; Epstein, 2015; Highfield, 2014; Lee, 2015; Merchant, 2015; Nacher et al., 2015; Siegle, 2013; Tootell et al., 2013). In addition, iPads are considered to be quite durable and, with appropriate protective coverings (Bower, 2012), can allow children's independent use with the knowledge that it is unlikely that the device will be damaged due to children's developing fine and gross motor skills. Moreover, iPads are also light and portable, hence allowing for little hands to manage and transport them to play locations of their choosing (Epstein, 2015; Siegle, 2013; Yelland et al., 2014; Zaranis et al., 2013). This allows educators to make available portable, easy to use, digital technologies within play settings

with a sense that children can autonomously use the devices, hence reducing constant educator monitoring of the play tool. Plowman and McPake (2013) warn, however, that whilst children are seen to have intuitive control over new technologies, unless devices and software are developmentally appropriate, children will still struggle to integrate the learning tools. Therefore, children will still need guidance and support whilst integrating new technologies. According to Pressey (2013, p. 8) educators who are 'very or moderately comfortable using digital games in the classroom also use games more frequently with their students'; therefore educators' willingness to adopt and use digital technologies will translate into more continued use. Thus, in order to feel more comfortable using digital technology appropriately within service delivery is the concept of training (Venkatesh et al., 2003). Being trained in how to use digital tools within the UTAUT2 model falls under the construct of 'facilitating conditions' (Venkatesh et al., 2012), which will be discussed in the next section.

2.8.3 Facilitating Conditions

Facilitating conditions fall within first-order barriers of technology integration (Blackwell, et al., 2014; Blackwell et al., 2013). When defining facilitating conditions, Venkatesh at al. (2012, p. 159) explain that it refers to consumers' perceptions of 'the resources and support available to perform the behaviour', which in this case would be the integration of digital technologies into early childhood settings. There is a need to understand how the use of digital technologies fits within current work styles and practices and how the integration of digital technologies can be supported by the infrastructure provided by the educational service. Venkatesh et al. (2003) describe that facilitating conditions do have an effect on users' participation with technology beyond that of behavioural intentions. For example, if leadership within an early childhood service mandated that digital technologies were to be implemented within their service, and provided training and resource for the implementation of digital technologies, this would outweigh other user acceptance constructs and the early childhood worker would be required to follow the edict given by leadership. Furthermore, Venkatesh et al. (2003) explain that help and support provided to users of technology over a sustained period of time will allow them to implement technologies in new and challenging ways, hence alleviating the potential of the devices to become stale or redundant. In addition, it is noted that older workers attach a greater importance to receiving help and assistance with the use of technology within the workplace (Venkatesh et al., 2003). Therefore, to have or

develop appropriate digital skills to use digital technologies effectively within early childhood settings becomes a crucial factor for successful integration of emergent digital technologies, and helps to form a link between first- and second-order barriers to assist in breaking down the second-order barriers to technology integration associated with attitudes and beliefs (Blackwell et al., 2013).

Educators need to have confidence and skills within the use of digital technologies, including participation with peers and colleagues within professional development opportunities (Blackwell et al., 2013; Blackwell et al., 2014; Blake, Gentry & Smith, 2012; NAEYC & Fred Rogers Centre, 2012). Grounded and digitally literate educators not only have the appropriate practice based upon their knowledge about child development theory, but they also have the skills and experience to select and use appropriate digital technology tools to suit their children's age as well as developmental level. By contrast, digital-illiterate educators may make poor choices, and consequently their children do not benefit from learning with the use of digital technology (NAEYC & Fred Rogers Centre, 2012). A challenge within the field of early childhood, according to Parette et al. (2013), is how early childhood educators can develop the knowledge and skills to successfully integrate digital technology into the curriculum. As stated by the NAEYC and Fred Rogers Centre (2012, p. 6), educators 'must be willing to learn about and become familiar with new technologies as they are introduced and be intentional in the choices they make'. Therefore 'early childhood educators need training, professional development opportunities, and examples of successful practice to develop the technology and media knowledge, skills, and experience needed' to successfully incorporate digital technology within early childhood settings (Blackwell et al., 2014; NAEYC & Fred Rogers Centre, 2012, p. 6). The study by Blackwell et al. (2013, p. 317) indicated that an increased frequency of professional development was a predictor of computer and tablet computer use. This is a point shared by Lee (2015), who explains that early childhood educators need to have support and experience in using digital technologies with young children in order to facilitate best practice.

Despite the need for training within the use of digital technology for young children, a major concern for the integration of technology into early childhood is that currently there is limited pre-service or in-service training to adequately prepare/adapt educators for the rapidly changing educational environment in which children are growing up (Parette et al., 2010;

Tokmak, 2013). Ntuli and Kyei-Blankson (2012) expand on this point by affirming that teacher education programs and professional development workshops need to develop technological and pedagogical knowledge, giving educators the skills and confidence to integrate technology within pedagogical practices for digital natives. They further state that funding bodies within early childhood have a duty to not only give early childhood services access to quality technological tools, but to also finance appropriate training and development.

The fiscal aspect of running an early childhood centre is paramount to effective delivery of outcomes for children and families (Rodd, 2013). Furthermore, there is an understanding that within early childhood in-service training budgets there is limited funding for opportunities to develop technological skills above and beyond what they already possess. Blackwell et al. (2013) indicated in their study that educators' highest educational attainment was also indicative of access to technology. They reason that educators with higher qualification may have the financial means to afford the technology themselves and are therefore confident and habituated users of technology and will seek employment in educational settings that fit their preferred pedagogical approach. Hence, the financial implication of training and affordability of purchase become an issue in relation to digital technologies' effective integration within early childhood settings. Thorpe et al. (2015, p. 181) gives a timely reminder to those determining early childhood budgetary priorities that 'only when resources are available will the next step, providing professional development to support safe and positive digital learning, become possible'. As with any business, financial constraints play a large role in dictating practice, hence the next section relates to the financial implications of integrating digital technology into early childhood services.

2.8.4 Price Value

Price value is defined by Venkatesh et al. (2012, p. 161) as consumers' (parents/educators purchasing digital technology for educational use) cognitive trade-off between the perceived benefits of the applications and the monetary cost of using them. The price value is deemed positive if the benefits of using the technology outweigh the financial cost of purchase and ongoing use. According to Venkatesh at al. (2012, p. 163) the effect of price value will be 'stronger among women, particularly older women'. A concern unrelated to children's development and wellbeing is the fiscal expense of digital technologies. Funding within many

preschool environments is tight and many of the digital technologies are both expensive, in comparison to other forms of play materials, and within the technological revolution they become out of date at a rapid pace (Shamir, Brown & Johnson, 2009). According to Siegle (2013) one of the benefits of mobile devices, such as the iPad, is that in comparison to laptops they are economically priced and the programs that run on them (Apps) are low-cost (sometimes free) in relation to other forms of software. Bower (2013) and Highfield (2014) warn that whilst many of the Apps available to consumers are free or 'lite' versions, consumers should be wary, as these Apps are full of advertising or promotions and often try to gain information from the user to manipulate purchases at a later date, and are not appropriate for young children. Additionally, within the rough and tumble world of early childhood education, there is the ever-present danger of digital technologies being damaged and rendered useless. Bower (2012) eases fears of durability by stating that, within her role as an early childhood practitioner, she talked to the children regarding the use and care of iPads within the learning environment and she has had very few issues with durability. Bower (2012) explains that this care by the children came as a process of constant exposure and forming appropriate technological habits in children. The notion of habit-forming practice is discussed in the next section.

2.8.5 Habit

When defining habit for the purposes of their model, Venkatesh at al. (2012, p. 161) explain that habit is based on experience and that continued use of technology can be a result of habit that comes from positive experiences. Research by Ertmer et al. (2012) on 12 K-12 teachers indicated that educators' personal positive attitudes towards, and experiences with, technology determined the continued effective use within pedagogical practice, thereby creating positive habits of behaviour. Conversely, in Blackwell's et al. (2013) study, 1,329 early childhood (0-4 years) educators showed that personal inhibitions to using technology did not predict actual use with children. This could be explained as the integration of digital technology into early childhood sectors is limited, hence limiting the opportunities for personal inhibitions towards technology influencing habitual practice or non-practice. Furthermore, data from 1,234 early childhood educators indicated that experienced teachers actually used digital technology more often, which would seem contradictory to concepts of "teaching the way you were taught" or experienced educators aligning themselves with more

traditional teaching approaches (Blackwell et al., 2014). However, Blackwell et al. (2014) discussed that, whilst younger and less experienced educators may have more familiarity with and positive personal experiences using technology, they do not possess the pedagogical knowledge to effectively integrate technology within the curriculum. The use or non-use of digital technology as a pedagogical tool will be discussed in the following section.

2.8.6 Digital Technologies as Teaching Tools

The TPACK model refers to technological pedagogical knowledge (TPK), which Chai et al. (2011, p. 1185) explain is 'knowledge of how technology can facilitate pedagogical approaches'. The self-reported use of technology as an instructional tool and learning resource within early childhood services is on the increase, (Ntuli & Kyei-Blankson, 2012) yet still scarce within preschool settings (Blackwell et al., 2014; Lindahl & Folkesson, 2012). Edwards (2013a) identifies that in many countries digital technology is not aligned with the dominant pedagogical model of play within the early years. Nevertheless, before digital technology can be merged as a pedagogical model for stakeholders in early childhood, it is important to understand that learning from screens is transferable to real life. This will be discussed within the concept of 2D/3D object response.

Linked to both cognitive and physical development is the ability for children to learn from a two dimensional (2D) sources (such as a tablet computer) and to translate that learning to three dimensional (3D) object response. Effectively, if children are not able to translate 2D images on a screen to 3D objects in real life then the potential for learning will be greatly diminished. Hayne (2004) stated that there are significant developmental changes in a "representational flexibility" which can occur in young children's learning process, and the gradual developmental change occurs because young children encode information in a variety of contexts and make use of different retrieval cues. Other researchers support that young children can form an internal mental representation of the target actions when demonstrated, depending on the features of the objects, context and model used during the demonstration (Bandura, 1986; Barr, 2010). It has been tested that there is a transfer of learning across content and context (Barnett & Ceci, 2002; Barr, 2010; Hayne, 2004). Furthermore, in specific relationship to questions asked within this study 'the use of real 3-dimensional objects and the transfer to 2-dimensional representatives through computer games is another important element of mathematical thinking' (Blake et al., 2012). Young children can learn

from books, television, touch screens and computers, as these can provide a specific form of transfer of learning from a 2D source to a 3D object response (Barr, 2010; Durkin & Blades, 2009).

Having identified that theoretically learning is indeed capable via digital technologies, and that the use of digital technology within early childhood is increasing (Ntuli & Kyei-Blankson, 2012), it is important to note there are very few empirical studies on the use of touch screen technologies within early childhood settings (Yelland et al., 2014). This makes it difficult for early childhood stakeholders to form clear, objective attitudes regarding digital play as a mainstream pedagogical model due to inconsistent information and ambiguity. The next section will analyse the attitudes that early childhood stakeholders have towards the use of digital technologies as pedagogical tools.

2.8.6.1 Attitudes to digital technologies as a technological/pedagogical tool

The use of digital technologies within early childhood settings is a controversial topic and one that creates debate amongst those with stakes in early childhood education (policy makers, early childhood directors and educators, as well as parents). As stakeholders, they will act as a filter to children's access to digital technology, determining the exposure that children will have, the scaffolding provided, and if the use of digital technologies can be integrated within play-based learning as digital play. Whilst there has been a great deal of "hype" regarding the integration of digital technologies within the field of education, there needs to be an understanding that digital technologies themselves are merely a vessel through which effective teaching pedagogies can be practised (Blackwell et al., 2014). According to Falloon (2013), an issue with emergent digital technologies is the disconnection between best practice utilisation and actual use. Whether it be that educators are not using digital technologies effectively or conversely that the "hype" created by sales companies does not, in reality, match effective pedagogies, creates a dilemma for the integration of digital technologies as educational tools (Blackwell et al., 2014; Blackwell, et al., 2013; Yelland et al., 2014). Ntuli and Kyei-Blankson (2012) suggest an additional reason as to the difficulty in gauging the effectiveness of digital technology, being that whilst educators are providing children with more technological tools, they do not know how to assess what students know or can do with that technology. Bower (2013) explains that current research regarding the use of gestural interface devices is in its infancy. The dearth of research-based evidence in general for the

use or non-use of digital technologies within early childhood is a major sticking point for advocacy (Blackwell et al., 2014; Kucirkova et al., 2014; Kucirkova, 2014) and subsequent acceptance of the pedagogical model of digital play.

The research available, however, points to the positive effects of technology on children's cognitive and social development within the field of education for children (Lee, 2015; NAEYC & Fred Rogers Centre, 2012; Zaranis et al., 2013). There is a perception that if early childhood educators do not embrace the use of digital technologies within their pedagogical practice, they will be "missing the boat" in terms of keeping up to date with 21st century teaching approaches (Parette et al., 2010; Parette et al., 2013). Winsor and Blake (2012) consolidate this theory when they suggest that due to the potential educational value of digital technologies, educators have a responsibility to critically examine the role that digital technology can play in early childhood environments to promote development. Some digital technologies are what Parette et al. (2013) refer to as instructional technologies; they have the benefit of potentially improving instructional: effectiveness, efficiency and appeal. Effectiveness is defined as 'helping young children do things in a better way' and efficiency as 'helping the child do things faster or of a better quality', whilst appeal is referred to as 'better engaging the child in learning' (Newby et al., cited in Parette et al., 2013, p. 171). The following sections explain how digital technologies are viewed as technological/pedagogical tools. It is framed within the UTUAT2, with effectiveness and efficiency (performance expectancy) and appeal (hedonic motivation).

2.8.6.2 Performance expectancy as a pedagogical tool

Within the UTUAT2 model, performance expectancy is defined as 'the degree to which using technology will provide benefits to consumers in performing certain activities' (Venkatesh et al., 2012, p. 159). According to Venkatesh et al. (2003) performance expectancy is the strongest behavioural indicator, both in terms of mandatory and voluntary use of technology. Hence if early childhood stakeholders do not believe that digital technology is meeting the developmental needs of children or fits within their preferred pedagogical approaches, they will choose not to use digital technologies and consequently not consider digital play as a play-based pedagogical model within early childhood settings. To highlight this notion, studies by Blackwell et al. (2014) and Blackwell et al. (2013) showed that if educators had a

strong agreement that technology can benefit children's learning, they used technology more often, even with historically passive/one-way communicative devices such as TVs/DVDs.

One of the primary distinctions within appropriate pedagogical tools for early learning is that it is the content that matters, not necessarily the manner in which it is delivered. Content is mediated in the manner educators utilise digital and non-digital tools for education purposes; likewise, inappropriate use of digital technologies will not prove effective as a teaching tool (NAEYC & Fred Rogers Centre, 2012). Educators must consider the manner in which they can utilise digital technologies for children's learning, communication and engagement (Blackwell et al., 2013; Lee, 2015; Rosen & Jaruszewicz, 2009). Effective technological tools have the ability to join educators and children together through on-screen and off-screen activities that allow the educator to link the digital world to the contextual world of the shared environment, therefore shared experiences rather than solitary (Lieberman, Fisk & Biely, 2009; NAEYC & Fred Rogers Centre, 2012). Attitudes towards the use of digital technologies as learning tools revolve around two premises: (1) can digital technology improve children's cognition? and (2) what are the socio-emotional ramifications of digital technology for the developing child? These two attitudinal questions will be addressed within the following sections.

2.8.6.3 Digital technology and children's developmental cognitive needs

In relation to the perceived benefits of digital technology for children's' cognitive development it is important to note that since the advent of educational hardware, associated software has been subject to debate as to relevance and educational value. Researchers such as Cordes and Miller (2000), Druin (2002), Plowman et al. (2010) and Struppert at al. (2010) state that whilst hardware such as computers, gaming consoles and tablets provide the platform upon which software can be navigated, the software and its application provide for authentic learning to take place. These researchers found that those resistant to the use of digital technology report that it is a waste of time for children and they doubt young children's readiness to use digital technology in terms of both cognitive and physical development. Cognitively, educators are worried that it is too abstract and difficult to use digital technologies and that learning objectives may get lost when children engage in complicated software not specifically tailored to their needs or learning styles (Plowman et al., 2010; Struppert et al., 2010). Kucirkova et al. (2014) concur, suggesting that the biggest

obstacle that Apps have in terms of fitting within the early years' pedagogical mainstream is the same historical issue about software, in that the contextual variance of use limits usability. Furthermore, Plowman and McPake (2013, p. 30) clearly explain that 'the extent to which children learn through technological play is disputed'.

In response to the nature of concerns regarding digital technology and its role within early childhood education, Haugland (2000) believes that children over the age of three are developmentally ready to explore technology. Research by Ellis and Blashki (2004) found that even very young children showed comfort and confidence using software. In a study with 100 early childhood educators, when asked 'which developmental areas of children do you intend to support most by using computers?', participants stated that cognitive development was the primary area of development (64.2%), followed by language development (52.6%), social and emotional development (40.0%), and psychomotor development (30.5%) (Yurt & Cevher-Kalburan, 2011, p. 1566). Therefore, there is a perception from educators that digital technologies are indeed assistive of learning within cognitive and other domains of development.

It has been shown that children can follow pictorial direction and use visual cues to understand and think about activities within software (Clements, 2002). In respect to types of software, Sarama and Clements (2003) explain that developmentally appropriate software should be addressed separately to other software types, because their educational impacts are different from each other. Gillespie and Beisser (2001) contend that appropriately open-ended educational software allows for children to have choice within their play and allows the user to take the initiative in their learning. Moreover, recent research into digital technology has shown that 'integrating technology as part of the learning process will promote academic achievement' (Shamir et al., 2009, p. 3347), with research confirming that digital technologies can help young children's learning (Clements & Sarama, 2007). Some of the reported cognitive benefits include increased attention span, creativity and problem solving skills, consistency, knowledge expansion and application, persistence, self-confidence and self-esteem within learning, development of metacognitive skills, mathematical skills and concept knowledge (Clements, 2002; Donahoo, 2014; Lee, 2015; Plowman & McPake, 2013; Tootell et al., 2013; Vernadkis, Avgerinos, Tsitskari & Zachopoula, 2005). In the study by Yelland et al. (2014) with kindergarteners, the use of iPads in a play-based setting highlighted

improved self-regulation and persistence whilst engaged with the touch screen technology. They also detailed that children who had difficulty sustaining concentration normally had no problems whilst engaged with the iPad. To expand on the value of digital technology in children's learning, in their literature review, Couse and Chen (2010, p. 76) explain that 'children who use computers have been found to show greater gains in intelligence, structural knowledge, problem solving, and language skills compared with those who do not use technology in their learning'. Plowman and McPake's (2013) case study with children about their technology use, found no evidence to suggest that technology use has detrimental impacts on children's behaviour, health or learning, and that children's day-to-day life does not revolve around the use of technology in a manner that impacts their play or physical activity, as media reports suggest.

Finally, from a pedagogical standpoint, opponents of digital technology raise two issues, the first being that it does not fit with children's need for open ended, real world, play-based concrete materials and the second being that digital technologies do not support authentic, hands-on experiences, but rather mediated or symbolic ones, hence leading to limited curricula development and not fitting within a traditional play-based curriculum (Struppert et al., 2010; Yelland, 2011). Edwards (2013a) argues that currently there is a divide between what educators understand about play in the early years and how children's use of emergent digital technology fits within their existing model of what constitutes play. Edwards further argues that 'new ways of thinking about play and technology are needed to address the gap between pedagogical perspectives on play and the use of technology in early childhood education' (2013a, p. 201). Edwards (2013a) also argues that the use of digital technologies within the social environment of the child allows for a range of play experiences that early childhood educators may or may not identify as being play.

Regardless of the ideological notion of defining play, historically within-play based learning environments it is argued that children learn cognitive skills by being scaffolded by adults and peers. One of the weakest elements of software associated with digital technology is its limited ability to provide specific feedback to the user to assist their understanding of process; rather software provides answers as to correctness (Sim's et al, 2006). Garris, Ahlers and Driskell (2002) defend digital technology by explaining that computer games promote active learning, in that learners learn by doing. The NAEYC and Fred Rogers Centre (2012, p. 7)

state that digital technologies mirror other forms of play within early childhood settings including 'sensorimotor or practice play, make-believe play, and games with rules'. Lee (2015) also explains that, given the dramatically altering landscape of children's play worlds, it is important that educators re-conceptualise exactly what play is in modern society. Bower (2012), who observed children in her care playing with iPads, suggests that children were in essence problem solving and exploring their digital worlds whilst engaged with appropriate educational Apps. Educators within Ntuli and Kyei-Blankson's (2012) study proposed that when children were using technology, they did not consider that they were 'learning' rather they were 'playing'. A study by Yelland et al. (2014) found that whilst children were engaged with iPads they observed a great deal of exploratory play occurring – exploratory play involves children having new experiences and understanding how their worlds operate (Berk, 2013). Verenikina and Kervin (2011) indicated in their study that children's use of an iPad App allowed the 'participant pre-schoolers to engage in a complex make-believe play that was supported' by the features of the iPad. Therefore, there is a changing dynamic of what constitutes play within modern play-based learning settings.

Within the concept of experience and children exploring their worlds, Grabe and Grabe (2007) also argue that certain phenomena are too difficult, or in some cases impossible, to observe, therefore the ability to observe and manipulate phenomena via digital technology allows for the learner to put objects into identifiable order they may not have been capable without technological assistance. For example, a child cannot experience a volcano first hand, yet through the use of digital technology can observe the phenomena and understand elements of the scientific processes at work. The NAEYC and Fred Rogers Centre (2012, p.7) and Plowman and McPake (2013) indicate that through technology children are able to extend their knowledge about their worlds though exposure to 'animals, objects, people, landscapes, activities, and places that they cannot experience in person'. Additionally, digital technology allows children and adults to record, save and revisit personal experiences and build upon these within appropriate teaching moments (NAEYC & Fred Rogers Centre, 2012). Furthermore, Lee (2009) argues that, in appropriately designed early childhood environments, children should have access to both adults and peers who can scaffold children's use of digital technology. The notion of appropriate scaffolding leads to the next section of social and emotional development and social interactions when using digital technologies.

2.8.6.4 Digital technology and socio-emotional development

From a social perspective, early childhood is seen as a time for children to develop the social, emotional and language skills needed for transition to school (Berk, 2013). The importance of social and emotional development on long-term positive learning outcomes for children is well documented (Brown, Winsor & Blake, 2012). Consequently, due to the believed adverse effects on preschoolers' social and emotional development (Armstrong, Donohue & Highfield, 2015; Brown et al., 2012; Tokmak, 2013), opponents of the use of digital technology within early childhood point to a number of factors for non-use. Digital technologies are feared to be addictive and socially isolating, minimising time spent with families and peers, inhibiting language development resulting in poor communication skills that are needed for school and beyond, fostering negative social and emotional outcomes, as well as taking time away from children's imagination and engagement with books (Bower, 2013; Brown et al., 2012; Finegan & Austin, 2002; McCarrick & Li, 2007; Plowman & McPake, 2013; Plowman & Stephen, 2003; Struppert et al, 2010; Yelland, 2011). The perceptions relating to children's socialisation, language development and imagination will be addressed further within this section in relation to current research on the topics, beginning with socialisation.

To address the context of children's socialisation, multiple studies have shown a wide range of both peer and teacher interactions and higher levels of social interaction when involved with computer play compared to more traditional solitary activities such as puzzles (Heft & Swaminathan, 2002; Muller and Perlmutter, 1985; Shahrimin & Butterworth 2001). In addition, studies have shown that children who have access to computers and developmentally appropriate software in the home are more likely to be school ready, from a holistic standpoint, for the transition to school (Haugland, 1992; Li & Atkins, 2004). Plowman and McPake (2013) suggest that, with the appropriate support, digital technologies can open up communication that spans time and distance and can allow children to develop new communication skills. Brown et al. (2012) and Clements and Sarama (2007) dispute the concept that computers are socially isolating, claiming that instead of isolating children, computers serve as a catalyst for social interaction. Their research found that children were engaged in high levels of social play and displayed positive emotions and stimulated vocalisations (Brown et al., 2012). A study by Yelland et al. (2014) with kindergarten

children using iPads in a play-based setting, demonstrated that the use of tablet computers allowed for both solitary and social play opportunities. Furthermore, Yelland et al. (2014) highlighted one of the major benefits of the use of iPads within the play-based setting, in that it allowed for conversation between both children and adults during its use. Lee's (2015) case study, involving three to five year old children's use of iPads in a play setting indicated that the use of iPads enhanced the frequency of interaction for children between peers and adults, as they were engaged in reciprocal problem-solving discussion relating to App tasks. Kucirkova et al. (2014) suggest that one of the primary reasons for children's ability to engage in productive communication whilst using gestural interface devices such as the iPad is the ease with which children can use these tools, therefore dedicating more time to collaboratively problem solve the learning task rather than trying to understand the technology. The above research indicates that language plays a major role within the social component of children's digital technology, however the notion that digital technology will impact negatively on children's language development is still a concern of early childhood stakeholders.

Early childhood is considered a time for children to interact socially, providing opportunities to engage in developmentally appropriate language experiences. Language is an essential element for school readiness, which opponents are worried is limited during children's use of digital technology owing to the isolated nature of certain forms of this technology (Ebbeck & Waniganayake, 2010). However, McCarrick and Li (2007, p. 88) explain that the research neither supports nor disputes these claims. They argue that no research has proven that digital technology, in this specific case the use of computers, enhances language, but that children do engage in a wide variety of language use whilst using digital technology, similar to other activities. Whilst there is a perception that parents use digital technology as a "babysitting" tool (Bower, 2013). Plowman and McPake's (2013) study suggests that parents used children's digital technology as a medium to begin conversation and discuss questions or interests the children have, allowing for children to develop their own narrative and imaginative responses.

When addressing children's imagination, researchers (Gillespie & Beisser, 2001; Haugland, 1992; 1996; Kervin, Verenikina & Rivera, 2015; McCarrick & Li, 2007) explain that open-ended software extends on children's imagination by allowing choices, which also develop

children's sense of initiative and increase their self-esteem and self-concept. This explanation is further discussed by Landy (2002, p. 245), who suggests that computers and associated software have not proven to 'reduce imaginative play, perhaps because there is an interactive component that offers some involvement in the process' and that 'for some children, the immediate feedback that video games provide can help them learn and remember things and these games can be satisfying activities'. Satisfaction and enjoyment with digital technologies will be discussed in the next section based on the UTUAT2 model of technology acceptance: hedonic motivation.

2.8.7 Hedonic Motivation

Within UTUAT2, Venkatesh et al. (2012, p. 161) define hedonic motivation as 'the fun or pleasure derived from using technology, and it has been shown to play an important role in determining technology acceptance and use'. Hedonic motivation has clear links to the acceptance and use of technology, however its influence fades with time and the novelty of the device is replaced by the functional element it provides (Venkatesh et al., 2012). As stated earlier, it is not recommended that children under the age of three use digital technology, however research also indicates that by age three, not only are children developmentally ready to use digital technologies, but they are effective and engaged users (Haugland, 2000). Supporters of developmentally appropriate use of digital technology within early childhood settings argue that digital technology involves children's strong motivation and engagement, therefore optimising learning (Mercer, 2014; McCarrick & Li, 2007; McKenna, 2012). Software can be more motivating and educationally effective by using animation and children's voices and giving simple, clear feedback (Clements & Sarama, 2007). Therefore, the use of such software designed to engage children also has strong links to children's sense of fun.

In addition to children's engagement with digital technologies, there has been an increase in research into the enjoyment or "fun" element of software designed for children (Blythe, Monk, Overbeeke & Wright, 2005). A study by Yurt and Cevher-Kalburan (2011, p. 1564) revealed that when early childhood educators were asked 'are activities, where you use computers, fun for children?', 80% of participants answered 'yes', 20% answered 'sometimes' and none answered 'no'. As identified earlier, children's engagement and enjoyment of an experience has an impact on their learning and subsequent achievement. As

suggested by Bower (2013, p. 5), 'iPads are fun to use, can make learning more exciting and enriching and support and enhance traditional learning'. Lee's (2009) study on pre-kindergarten children's engagement with computers showed that children's level of engagement and enjoyment was higher in children who possessed or were given appropriate scaffolding in computer skills. Lee's (2015, p. 949) study also found that children had increased levels of engagement and learning whilst using iPad Apps and that children had an increased motivation to learn 'because their interactions with digital media were engaging and fun'. Therefore, children's engagement and enjoyment of digital technologies can be seen as a tool to enrich children's cognitive development and achieve curricula outcomes (Kucirkova et al., 2014). However, regardless of children's engagement and enjoyment, consideration is needed as to the developmental appropriateness of digital technologies for young children and whether digital technology can indeed educate, rather than just stimulate children. Therefore, an important component of analysing whether children's use of digital technologies translates into the pedagogical model of digital play is if, along with children's engagement and enjoyment of digital technology, children also achieve learning outcomes, thereby fitting within curricula requirements for children's learning achievements within play-based settings.

2.9 Digital Technologies and the Early Childhood Curriculum

Technological content knowledge (TCK) is defined as 'knowledge of how content can be researched or represented by technology' (Chai et al., 2011, p. 1185). Within current educational philosophies one of the tools that early childhood educators are encouraged to teach is the technology curriculum (Kucirkova et al., 2014; Lindahl & Folkesson, 2012; Ntuli & Kyei-Blankson, 2012; Tootell et al., 2013). Within the EYLF (DEEWR, 2009, p. 46) the term 'technologies' includes:

> *much more than computers and digital technologies used for information, communication and entertainment. Technologies are also the diverse range of products that make up the designed world. These products have been extended beyond artifacts designed and include processes, systems, services and environments.*

Whilst this research focuses specifically on digital technologies, the use and teaching of technologies are embedded within the EYLF; however there are two specific references

within Learning Outcomes 4 and 5 to the use of technology with young children. Outcome 4 (DEEWR, 2009, p. 37), states that 'children resource their own learning through connecting with people, place, technologies and natural and processed materials'. Learning examples include when children 'use information and communication technologies (ICT) to investigate and problem solve'. Educators can promote this outcome as they 'introduce appropriate tools, technologies and media and provide the skills, knowledge and techniques to enhance children's learning'. Outcome 5 (DEEWR, 2009, p. 44) states that 'children use information and communication technologies to access information, investigate ideas and represent their thinking', learning examples include when children 'engage with technology for fun and to make meaning'. As explained by ACECQA's National Educational Leader, Rhonda Livingstone (2015, para. 4) that when providing emergent technologies there are many points to consider, such as time spent using technology, privacy, appropriateness of content and how the use of technology may be incorporated into the educational program'. As suggested with the EYLF, play is the preferred pedagogical model used within educational programs (DEEWR, 2009).

Educators can promote Outcomes 4 and 5 when they 'integrate technologies into children's play experiences and projects'. There is a need for educators to be able to comprehend the function and use of digital technologies within play, and ultimately understand how to assess the effective use of these devices (Bird & Edwards, 2014). That technologies can be 'integrated' into play highlights Edward's (2013a) notion that within curriculum documents designed for the early years, there is still a disconnect between the dominant pedagogical practice of play and technologies associated with digital technologies. They serve as a means to an end, to meet outcomes (as is the case within the EYLF). Therefore, full integration of digital play as an appropriate pedagogical model has not been addressed within the EYLF despite the societal changes in the use of digital technologies. As explained by Livingstone (2015, para. 5) "using digital touch technologies in your program is optional, and you [educators] need to think about the best way to use these technologies to support each child's educational program". Whilst not considered as mandatory in use, clearly Outcome 4 and 5 (DEEWR, 2009) highlight the role of digital technologies within the EYLF, the learning outcomes clearly indicate it is anticipated that early childhood educators will indeed integrate technology into practice with an expectation they will facilitate outcomes.

According to the NAEYC and Fred Rogers Centre (2012) when educators are trained and confident within the use of digital technology, they use appropriate technology-supported activities to meet learners' needs, pedagogical styles and curricula expectations. The ability to link appropriate digital technologies to curriculum documents, in this case the EYLF, requires an educator who is well versed and confident in their own technological skills as well as in how to plan for young children. Ntuli and Kyei-Blankson (2012) state that digital technology integration within early childhood curriculum has increased and their survey conducted with early childhood educators, found that over half of the 56 participants stated that the most frequent digital activity children engaged in was educational games, specifically maths and literacy related games. Yurt and Cevher-Kalburan's (2011, p.1566) study with 100 early childhood educators, asked, 'in which activities in your education program do you give place to computer usage most?' The responses included music activities (62.1%), preparation for reading and writing (45.3%), math activities (33.7%), science-nature activities (30.5%), game activities (29.5%), language activities (28.4%), drama activities (26.3%) and art activities (25.3%). In a review of research articles on young children's (0-8 year-olds) learning through technology during the period from 2008-2013, Hsin and Tsai (2014, p. 90) identified that of the 94 studies 83 focussed on cognitive learning, with a focus on language and literacy (n=47), digital literacy (n=19), math (n=12) and science (n=6). The ability of digital technology as a tool to teach curricula outcomes, specifically numeracy, is the focus of the next section.

2.10 Digital Play to Teach Numeracy in Preschool Play Contexts

The final level of the TPACK model is the technological pedagogical content knowledge (TPACK). Within this level 'knowledge of facilitating students' learning of a specific content through appropriate pedagogy and technology' is the principle (Chai et al., 2011, p. 1185). For this research, that content area is numeracy. Within the area of numeracy, digital technologies are considered effective tools to achieve numeracy-based outcomes (McKenna, 2012; Powell & Ray, 2012; Zaranis et al., 2013). Highfield (2010) as well as Powell and Ray (2012) argue that the use of digital technologies can assist children to learn numerical concepts and conceptual skills such as patterning, units of area and length, ratio and proportion, number and spatial awareness, whilst utilising problem solving strategies and virtual manipulatives. Clements and Sarama (2005b) use the example of children's

development of geometric concepts by using digital technology to manipulate shapes in contexts different to those they would be able to do with regular shapes and puzzles. Clements (2002, p.165) argues that digital technologies allows children to 'form strong, valid mathematical ideas'; Goodwin (2010) and Perry et al. (2008) furthermore suggest that digital technology allows for children to not only learn expected ideas, but also be exposed to a new variety of ways of explaining abstract numeracy concepts and that research needs to keep abreast of the impact of technology on children's numeracy learning to maximise potential.

The National Council of Teachers of Mathematics (NCTM, 2003, p. 1) describe technology as 'an essential tool for teaching and learning [numeracy] effectively; it extends [numeracy] that can be taught and enhance students learning'. Further elaborated by Presser and Busy (2016), technology allows children to understand numeracy in real-world models to increase their active participation and interest. As was explained in Section 2.8.7, there is a hedonic motivation to children's use of digital technology, which allows for children to be engaged and consequently have opportunities for learning. Whilst Highfield (2010) agrees that technology-based tools allow for exposure to a wider range of numeracy ideas, she argues that such exposure does not mean that children will grasp these ideas; in fact they may just wash over the children without application or understanding. Therefore, educators must ensure that the selection of software as a pedagogical tool meets the children's current stage of numeracy development and that educators are selecting appropriate criteria for children's application and development.

As an appropriate pedagogical tool to teach numeracy, Clements and Sarama (2007, p. 143) argue that the advantages of using digital technology is that appropriately designed software has the unique advantage of being able to take abstract numeracy concepts and turn them into actions, allowing children to link representations, provide feedback and be guided along a research-based trajectory. Attard and Northcote (2011), Riconscente (2013) and Blake et al. (2012) agree with this premise and explain that software design has been successful in integrating learning and motivation; allowing children to explore and be challenged in ways that make failure of a component of the learning process without the consequences often associated with traditional based learning and assessment. Furthermore, Riconscente (2013) suggests that the game play associated with software design engages the learner within content. Scanlon, Buckingham and Burn (2005) agree and explain that digital technology has

considerable potential to allow children to learn and be engaged with numeracy within the context of their own development. Furthermore, in relation to children's experience of new numeracy concepts discovered via software, Thrupp (2003) explains that it gives learners the opportunity to adapt pre-existing knowledge in new ways, thereby allowing learners to recognise similarities and differences within concepts, leading to accuracy and efficiency in learning as they receive immediate feedback from the software (Clements & Sarama, 2005c).

Fitting within children's developmental characteristics, as discussed earlier, the specific interface used with emergent technologies, such as the Apple iPad, includes a gestural interface. Gestural interfaces allow for embodied interactions which link appropriately to the way young children learn numeracy via gestures (Riconscente, 2013). Goldin-Meadow, Cook and Mitchell (2009) indicate that children produce a particular set of gestures while learning new numeracy concepts of grouping, which aid in the retaining of knowledge and solving problems. Other researchers also found that children use gestures in numeracy frequently as a problem-solving tool (Carlson, Avraamides, Cary & Strasberg, 2007; Wasner, Moeller, Fischer & Nuerk, 2013). Apps that utilise a gesture-based operating system should therefore maximise the interface's learning potential and allow children to develop numeracy knowledge similar or beyond that of traditionally based learning. A study by Zaranis et al. (2013) with children aged four to six years attending kindergarten, which compared tablet-based numeracy learning to traditional teaching methods, found that tablet computers aided learning compared to the traditional teaching methods. Likewise, in a study involving fourth grader learning of fractions, Riconscente (2013) found that significant increases were seen in students' test scores for those using the application "Motion Math" on iPads to learn the concepts, compared to the traditional based learning of the control group. Perry et al (2008, p. 33) argues that in terms of future numeracy research, the study of technology in the numeracy education of young children is necessary to assist in the understanding of potential best practice. To understand how numeracy-based Apps can promote learning it is important that educators are able to identify what numeracy-based Apps do, and what their purpose is, by categorisation, which will be discussed in the next section.

Attard and Northcote (2011, p. 30) point out that there are 'literally thousands' of numeracy Apps available for download, and as Blake et al., (2012) explain, not all software designated for young children's numeracy education is appropriate. Hence educators need to be aware of

the purpose of the software and whether it is developmentally appropriate. According to Siegle (2013, p. 147) ‘Apps generally fall into six categories: productivity Apps, subject-specific productivity Apps, information-gathering Apps, game Apps, drill and practice Apps, and social media Apps’. To appraise numeracy Apps, research conducted by Handal et al (2014) used the TPACK framework to develop an instrument to appraise the role of mobile math Apps. Their instrument is categorised into four parts. The first part asks the educator to identify the primary role of the App, this being either explorative, productive or informative. Parts two to four ask the educator to identify the cognitive engagement, general pedagogical issues and finally operational issues, thereby allowing the educator to make informed decisions as to the role and purpose of numeracy Apps so as to fit within the context of the educators’ and children’s pedagogical needs.

Researchers Johnson and Christie (2009, p. 284) suggest that software designed for young children ‘is problem-solving oriented and open-ended, children tend to engage in creative play and interact with peers in a positive manner. On the other hand, drill-and-practice programs can be quite boring and limit children's initiative and decision-making’. Kucirkova et al. (2014) suggests that open-ended Apps promote desired outcomes such as higher levels of engagement and exploratory talk, which are associated with academic success. Likewise, Mercer (2014) argues that Apps that support children’s research and investigation skills, in a process over product style, make a significant difference in children’s development compared to repetitive skill-based drill and practice style Apps. This point is strengthened by the HighScope Position Statement on Young Children and Technology, where they state that software ‘should be interactive and open-ended, and it should promote discovery learning, not emphasise drill and practice’ (Epstein, 2015, p. 7). Livingstone (2015, para. 8) strengthens this point by explaining that “instructive apps align with rote learning approaches and require a low level of cognitive investment”. Blake et al. (2012, p. 216) further explain that in relation to drill and practice-styled software, such software ‘may lead to certain rote skills but not be as effective in improving children’s conceptual understanding of mathematical ideas’. However as noted by Attard and Northcote (2011), many of the Apps available for young children’s numeracy only focus on the drill and practice through games.

Highfield and Goodwin's (2013) study analysed educational Apps for preschool-aged children and discovered that 74% of Apps were considered instructive styled, with instructive Apps containing elements of drill-and-practice design. Researchers such as Varol and Colburn (2007) discuss that there is a need for children to practice and replicate numeracy skills and drill-and-practice software allows for this to occur. Armstrong et al. (2015, p. 29) explain that drill-and-practice styled Apps 'may be seen as appropriate for a range of educational skills, like basic facts in [numeracy]'. However, as pointed out by Highfield and Goodwin (2013, p. 384), it is optimal for software to be 'constructive', thereby allowing children to have open-ended learning opportunities that give them a greater sense of control over their learning. Highfield and Goodwin (2013, p. 384) further discuss that the prevalence of instructive-styled Apps may reflect App designers' entrenched philosophical position on what constitutes [numeracy] and that these Apps are popular as they reflect specific curriculum and skill practice. Therefore, educators and parents will need to make informed decisions in relation to the appropriateness of the software for young children's numeracy learning and what fits within their preferred pre-existing pedagogical methods. In this study it is proposed that the use of digital technologies fits within a pedagogical model for learning that when implemented constitutes digital play and therefore has the potential to assist young children's numeracy learning outcomes.

2.11 Development of Research Questions

Digital technologies are becoming more prevalent in early childhood settings, therefore understanding and attitudes towards issues around digital technology must be explored. Beliefs about the use of digital technologies within early childhood settings begin to alter to accommodate the change in information transference. Yet currently there are two primary limitations within current literature justifying stakeholders' positions regarding the use and relevance of digital technology for young children. Firstly, there is little empirical evidence to validate either side of the debate, generally each side revolving around theoretical or philosophical values and belief (Blackwell et al., 2014; Evans Schmidt & Vandewater, 2008; Kucirkova et al., 2014; McCarrick & Li, 2007; NAEYC & Fred Rogers Centre, 2012; Plowman & McPake, 2013). There is foundational literature regarding young children's television viewing and screen time (NAEYC & Fred Rogers Centre, 2012), however there is not enough research informing early childhood stakeholders on the use, engagement and

enjoyment that preschool children have with interactive screens, such as Apple's iPad, and children utilising a gestural interface; rather recent studies have focused on older children and adolescents (Kucirkova et al., 2014; Tootell et al., 2013). Yelland et al. (2014, p. 14) suggests that since iPad's introduction into the market in 2010, there has been 'limited empirical research about their use in educational settings'; a point supported by others, such as Kucirkova et al. (2014) and Riconscente (2013), who articulate that despite the advertised claims that iPad Apps are educational, there is limited empirical evidence that validates these claims as more than promotional advertising. Secondly, some debates are too broad and do not focus on specific stages or domains of development, hence lead to misinformation regarding the holistic development of digital technology for the user (Couse & Chen, 2010; McCarrick & Li, 2007; Tootell et al., 2013). Rather, the majority of media coverage revolves around the advantages and disadvantages of children being exposed to media and screens (Plowman & McPake, 2013). In a study by Palaiologue (2014) of 540 families, the consensus view of parents was that 'media, research and education should be worried about how digital technologies can be used for children's learning … rather than pointing out advantages and disadvantages'. Consequently, a major limitation in the argument about the use or non-use of digital technology in preschool settings is the limited substantiated empirical evidence, which is specifically designed with developmentally appropriate claims. As Kucirkova et al. (2014) point out, with the advent of a developmentally usable learning tool for children and with a large quantity of Apps available for use, the time to consider how to use and validate use is now. Furthermore, Riconscente (2013, p. 190) points out that 'to date there has been no experimental research to ascertain whether these Apps promote children's learning [of numeracy]'.

In light of the above literature, the present research will investigate early childhood stakeholders' attitudes to the use of digital technologies and to what degree does three to four year old children's engagement and enjoyment with software via touch screen technology increase their numeracy learning outcomes.

The sub-questions are framed within the Digital Play model (Figure 2.5); when digital technologies are integrated appropriately within early childhood, play-based settings then they have the potential to be categorised as digital play. Questions include:

1. Are digital technologies being used with children aged 3-4 and what are the prevailing

attitudes that child care educators (directors, teachers and carers) and parents have towards the integration of digital technology?

1.1. Do child care educators (directors, teachers and carers) and parents believe that gestural interface devices are developmentally appropriate for preschool education or not?

1.2. Do child care educators (directors, teachers and carers) and parents believe that Apps (software) designed for preschool education are developmentally appropriate or not?

2. What are the primary roles of the most popular Apps designed for preschool aged children's numeracy learning and are the Apps designed developmentally appropriate for children?

3. To what level do 3-4 year old children engage, enjoy, and learn numeracy concepts via play with gestural interface devices?

3.1. To what level are 3-4 year old children engaged with games using a gestural interface device?

3.2. To what level do 3-4 year old children enjoy using games via a gestural interface device?

3.3. To what degree does the use of games using a gestural interface device have on 3-4 year old children's ability to learn numeracy concepts?

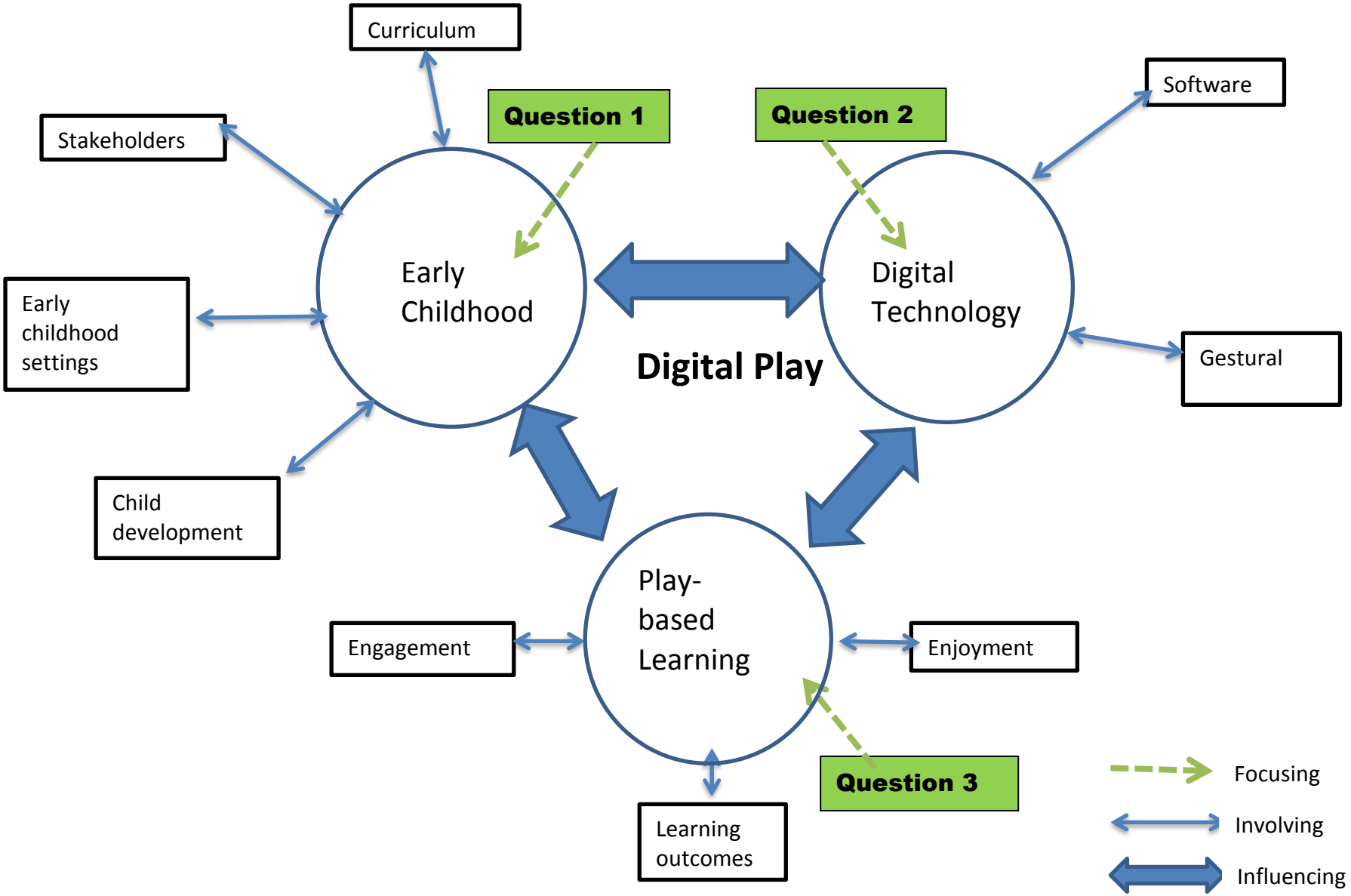

Figure 2.5. Framework of the research and development of three research questions within the Digital Play model.

2.12 Summary

This literature review was grounded within the Technological Pedagogical Content Knowledge (TPACK) framework. The review highlighted the role of digital technology within early childhood contexts, underlining that digital technologies are becoming integrated within society yet full integration into early childhood educational settings has yet to occur. Furthermore, there continues to be a disconnect between the dominant early childhood pedagogy of play and the use of digital technologies with young children; rather digital technologies are seen as a tool to support play rather than a specific genre of play, digital play. There are gaps within our knowledge of why digital technologies have yet to attain full integration, such as Australian early childhood stakeholders' attitudes towards the integration of digital technologies. Attitudes affect behaviour and without an understanding of current attitudes, successful integration of digital technologies will not be possible. One of the factors influencing digital technologies' integration into early childhood is the limited empirically based studies that validate the value of digital technology in terms of developmental appropriateness for young children and impact on children's learning outcomes. Therefore, it is timely to validate current philosophical arguments to justify the level of integration of digital technologies and to determine moreover if digital technologies can be their own model of play within the early years. The next chapter will outline the specific methods and methodological approaches adopted by the researcher to answer the questions asked within this study.

Chapter III: Research Methodology and Design

3.1 Introduction

The purposes of this research was to investigate early childhood stakeholders' attitudes towards the use of digital technologies and to what degree 3-4 year old children's engagement and enjoyment with software via touch screen technology develop the ability to learn numeracy concepts.

The study investigated the following:

1. Are digital technologies being used with children aged 3-4 and what are the prevailing attitudes that child care educators (directors, teachers and carers) and parents have towards the integration of gestural interface technology into child care settings?
   1.1. Do child care educators (directors, teachers and carers) and parents believe that gestural interface devices (hardware) are developmentally appropriate for preschool education or not?
   1.2. Do child care educators (directors, teachers and carers) and parents believe that Apps (software) designed for preschool education are developmentally appropriate or not?
2. What are the primary roles of the most popular Apps designed for preschool aged children's numeracy learning and are the Apps designed developmentally appropriate for children?
3. To what level do 3-4 year old children engage, enjoy, and learn numeracy concepts via play with gestural interface devices?
   3.1. To what level are 3-4 year old children engaged with games using a gestural interface device?
   3.2. To what level do 3-4 year old children enjoy using games via a gestural interface device?
   3.3. To what degree does the use of games using a gestural interface device have on 3-4 year old children's ability to learn numeracy concepts?

To answer these questions, the research project was carried out in three phases using a mixed methodological approach. Phase 1 – used survey data to collect information on educators' and parents' perceptions and use of digital technology in early childhood. Phase 2 – used App

rating scales to evaluate the developmental appropriateness and function of 50 numeracy Apps designed for preschool aged children. Finally, Phase 3 – involved observation and recording of children's engagement, enjoyment and numeracy learning whilst pre- and post-exposure to digital technology. Quantitative data from each phase was analysed using the Statistical Package for Social Science (SPSS) Version 22 and alpha was set at 0.05. Coding (Wiersma, 2000) was used to develop concepts from the raw qualitative data. Axial coding, open coding, and preliminary coding were used in the process. Where relevant, various demographics of the data are discussed as are measures of reliability or validity. The following sections describe the methodology used to approach these problems and the methods employed in each phase.

3.2 The Research Approach

A mixed methods approach of both quantitative and qualitative methods was used in this research to identify the use of digital technologies in early childhood settings. Mixed methods research has been considered as surveys, grounded theory and experiments (Ary, Jacobs & Sorensen, 2010). A mixed methods research occurs in single or multiphase study. Ary et al. (2010) state that it is worth considering a mixed methods approach if it offers a better understanding of the research problem than a single method design. In a mixed methods approach, different types of data collecting methods are employed – for example, both survey and archival data. Yin (2006) states that mixed methods research is not just two distinctly separated studies; rather it is a purposeful and logical blending of the qualitative and quantitative methods within the design. The common identified purposes for conducting mixed methods research include triangulation, complementarity, development, initiation and expansion (Ary et al., 2010). To achieve the purpose, the researcher must look at a number of factors in designing a mixed methods approach. Hence the rationale for selecting such a methodology is outlined in the following sections.

3.2.1 The Rationale for a Mixed Methods Approach in This Study

This study is to use mixed methods approach. Mixed method approaches involved planned use of two or more different kinds of data gathering and analysis techniques (Greene, Kreider & Mayer, 2008). Using mixed methods approach (quantitative with qualitative) in education research is becoming increasingly common (Creswell, 2013; Creswell & Plano Clark, 2007).

Green et al. (2008) further state that use of a mix-method approach offers a different form of better understanding in the four areas: a) more defensible understanding with stronger validity or credibility and less known bias; b) more comprehensive understanding with more complete and full portraits; c) more insightful understanding with new ideas, fresh perspectives, creative concepts and meanings; and d) more inclusive understanding with greater values consciousness and with greater diversity of values, stances and positions. There are three phases in this study – the survey phase, App review phase and child play phase. During these three phases, data are collected and examined in one stage to inform the data collected in the next phase. This design is properly described in one of the six mixed methods designs – sequential designs (Creswell, 2013). In sequential design, data analysis begins before all the data are collected and the analysis may influence choices made in conducting the next phase of study. The basic rationale for this design is that it uses the results from one approach to develop or inform the other approach. This belongs to one of the common identified purposes for conducting mixed methods research: development. In development, the study can begin with qualitative or quantitative data analysed in the first phase as a way to establish constructs to be measured quantitatively or qualitatively in the following phase(s) (Creswell, 2013). By using this mixed methods approach, this study can provide both statistical and textual data (see Figure 3.1). In this study, parents' and educators' attitudes towards use of digital technologies were first studied and analysed before the app review phase and child play phase.

This research also involved seeking elaboration and illustration of the findings from one method using results from the other. In this study, parents' and educators' attitudes towards the use of digital technology were researched via surveys, including open-ended and close-ended questions to determine the influences on their perceptions of the use of digital technology. This studying of stakeholders' opinions was also combined and compared with quantitative measurements to determine the learning outcomes of their own children's use of the digital technology. This rationale is to use different approaches to measure different facets of a single phenomenon (Ary et al., 2010; Creswell, 2013). However, in this study, one design is nested in another (see Figure 3.1). The rationale for this is set out in the next section of Research Design.

3.2.2 Research Design

Phase 1 – survey aims to answer the first research question: "Are digital technologies being used with children aged 3-4 and what are the prevailing attitudes that child care educators (directors, teachers and carers) and parents have towards the integration of gestural interface technology into child care settings?" Sub-questions included: a) do child care educators and parents believe that gestural interface devices (hardware) are developmentally appropriate for preschool education or not? and b) do child care educators and parents believe that Apps (software) designed for preschool education are developmentally appropriate or not? Pilot studies were done to develop the surveys for child care educators and parents. The differences between the attitudes from child care educators and parents were also compared, and educators' and parent's influence on 3-4 year old children's engagement with using iPads and Apps. Figure 3.1 shows an outline of the research design of the project. Based on the results from the questionnaires, the math Apps were rated by child care educators and parents (question 1.2) as the most developmentally appropriate software for children (3-4 years of age). A repeated measures ANOVA revealed significant effect among numeracy Apps, literacy Apps, science Apps, arts Apps, and PE Apps, $p < .01$. The results and findings about the use of Apps in child care centres from this phase helped to generate and choose the appropriate Apps for review in Phase 2. The findings about the opinions from the stakeholders in Phase 1 were used to compare with the findings from the Phase 3 (child play) so that different approaches (Ary et al., 2010; Creswell, 2013) were used to measure the leaning outcomes of the digital technologies in child care centres.

Phase 2 – App review was used to answer the second research question: "What are the primary roles of the most popular Apps designed for preschool aged children's numeracy learning and are the Apps designed developmentally appropriate for children?" Finally, based upon the results from the questionnaires, the gestural interface devices were rated quantitatively as developmentally appropriate for children aged 3-4 years. The results from this phase were used to compare with the results using a play-based pedagogy in Phase 3.

Phase 3 – Child play was designed to answer the third research question: "To what level do 3-4 year old children engage, enjoy, and learn numeracy concepts via play with gestural interface devices?". Included were sub-questions: a) to what level are 3-4 year old children

engaged with games using a gestural interface device? b) to what level do 3-4 year old children enjoy using games via a gestural interface device? and c) to what degree does the use of games using a gestural interface device influence 3-4 year old children's ability to learn numeracy concepts? In this phase, the engagement, enjoyment and learning outcomes of digital technologies were investigated. These findings were compared and investigated with the results from Phase 1. In detail, the learning outcomes of children's use of digital technology were compared with the opinions from the stakeholders, in particular the access and use of digital technologies at home, and parents' and early childhood educators' opinions, which involved much further discussion of the current opinions and attitudes from stakeholders towards the use of digital technology in child care centres, and whether or not children can learn (in this study numeracy concepts) from digital technology. Moreover, findings from observation qualitative data collected from this phase were also investigated together with the appraisal of the Apps from Phase 2.

To have a fuller and clearer picture, Figure 3.1 shows the research design of three phases. In each of these phases, the data were analysed to identify: (a) App quality for 3-4 year old children's developmental appropriateness, (b) child care centre educators' attitudes towards the use of digital technology, (c) parents' attitudes towards the use of digital technology with young children, (d) 3-4 year old children's engagement in playing touch screen technology, (e) 3-4 year old children's enjoyment in playing with touch screen technology, and (f) the impact of touch screen technology games on 3-4 year old children's ability to learn numeracy concepts.

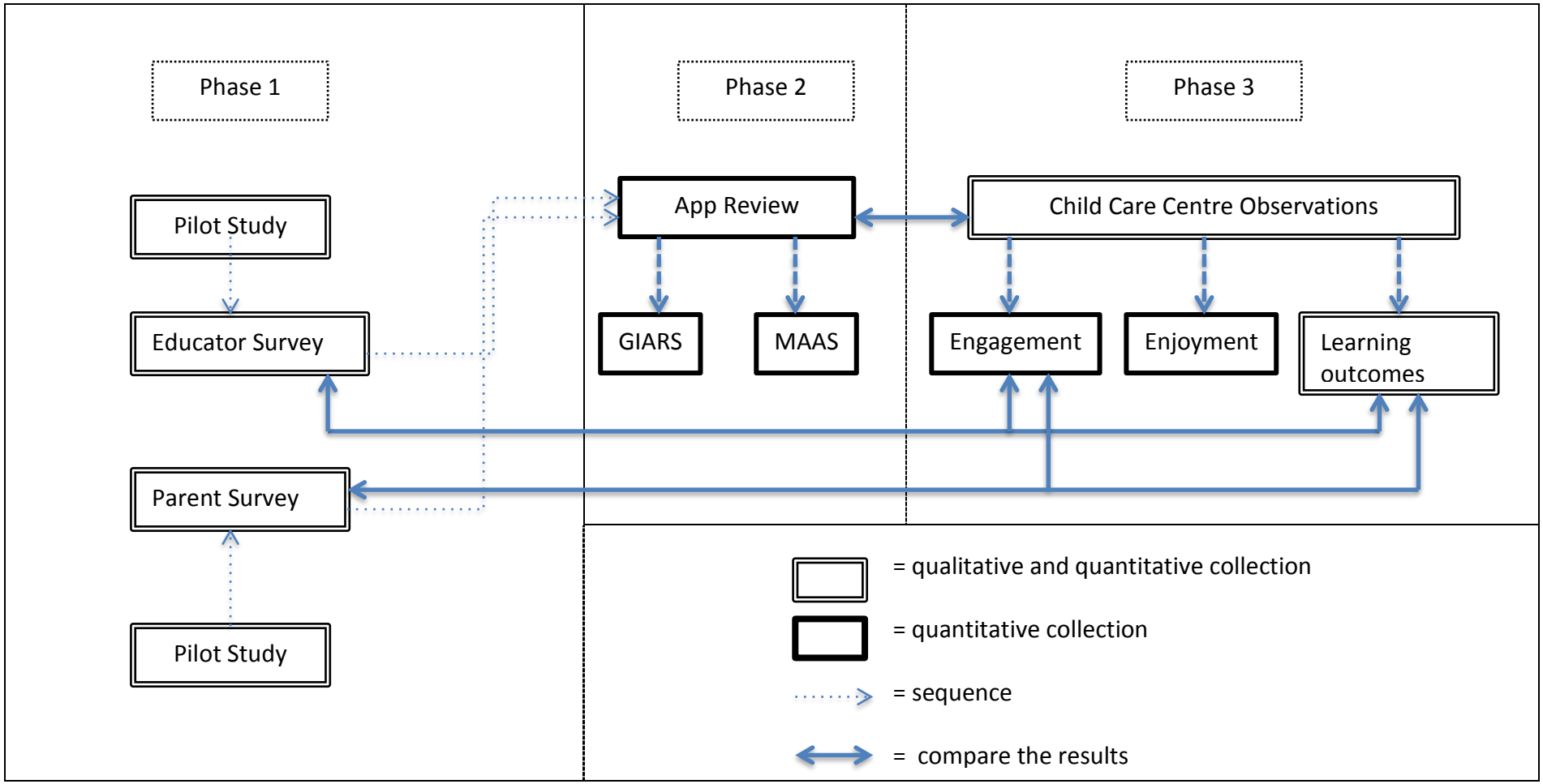

Figure 3.1. The research design.

Phase 1. A pilot study was undertaken to develop the instruments for the surveys. Kervin, Vialle, Howard, Herrington and Okely (2016) advise that pilot studies inform researchers about their instruments to ensure that they can accurately reflect the time needed for participants to complete the instrument as well as the ease and appropriateness of questions, thereby allowing for the full study to run smoothly. The surveys were administrated to 5 educators and 5 parents at child care centre sites. Gay, Mills and Airasian (2015) and Leedy and Ormrod (2013) stated that survey research involved acquiring information about one person or a group of people.

A total of 49 child care educators and 80 parents, of children aged 3-4 years, participated in the survey at the participating child care centres. Parents of 80 children participated in the questionnaire survey on site also. Table 3.1 provides an overview of the phases.

Table 3.1

Overview of Research Data Collection Phases

Phase	Participants	Data Collection Method
1. Survey	Pilot study – Educators (*N* = 5) Pilot study – Parents (*N* = 5) Survey – Educators (*N* = 49) Survey – Parents (*N* = 80)	Questionnaire survey
2. App review	Apps (*N* = 50)	Apps review
3. Child play	Children (*N* = 80)	Observation Experimental research

The intention of the surveys was to compare the differences among the attitudes from child care educators and parents, and measure the potential relationship of their attitudes on 3-4 year old children's engagement with iPads (see Figure 3.2).

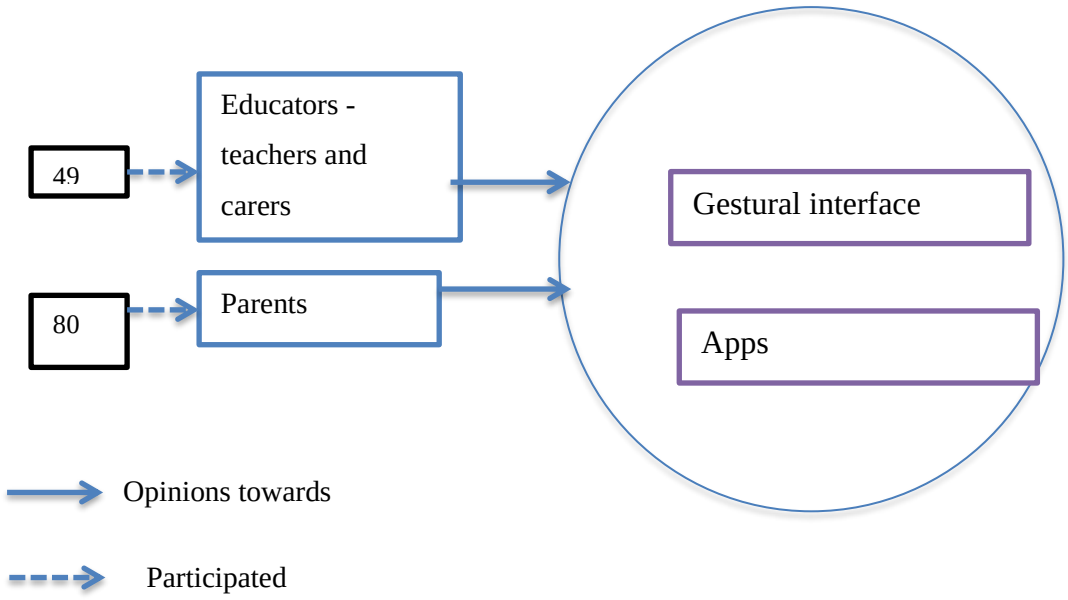

Figure 3.2. Survey phase.

Phase 2. Fifty early childhood numeracy Apps were chosen from the Game Centre component of the Apple website. Using the Gestural Interface App Rating Scale (GIARS) developed from the Haugland Scale (Haughland & Wright, 1997) and a maths App appraisal instrument, developed based on the TPACK model (Mishra & Koehler, 2006), this phase was used to find: a) the quality of the apps for 3-4 year old children's developmental levels, and b) the Apps' primary roles. The five highest scoring Apps were chosen to be used in Phase 3 (see Figure 3.3).

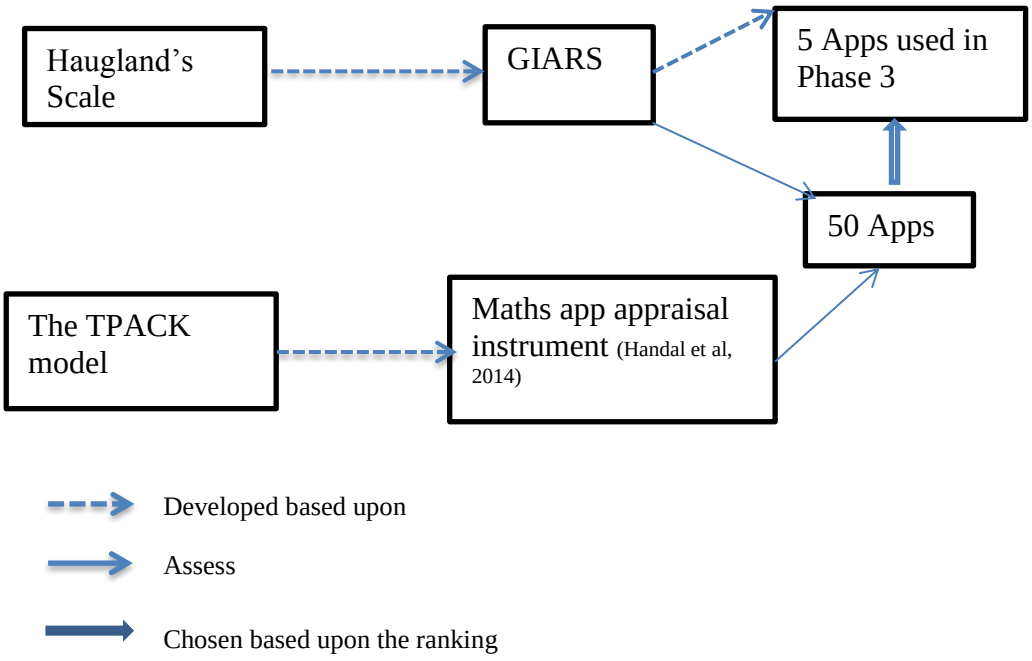

Figure 3.3. App review phase.

Phase 3. Eighty 3-4 year old children participated in this phase. The age of children is important because: a) limited studies have been done on the use of digital play in early childhood settings, and b) children younger than 3 learn through their bodies – their eyes, ears, mouths, hands and legs, and the developmental skills these children are learning to master are crawling, walking, talking and making friends (Haugland, 2000), and (c) that screen time is not recommended for children aged 2 years and under (AAP, 2011). Within the onsite phase are three sections which measure numeracy outcomes, engagement and enjoyment (see Figure 3.4).

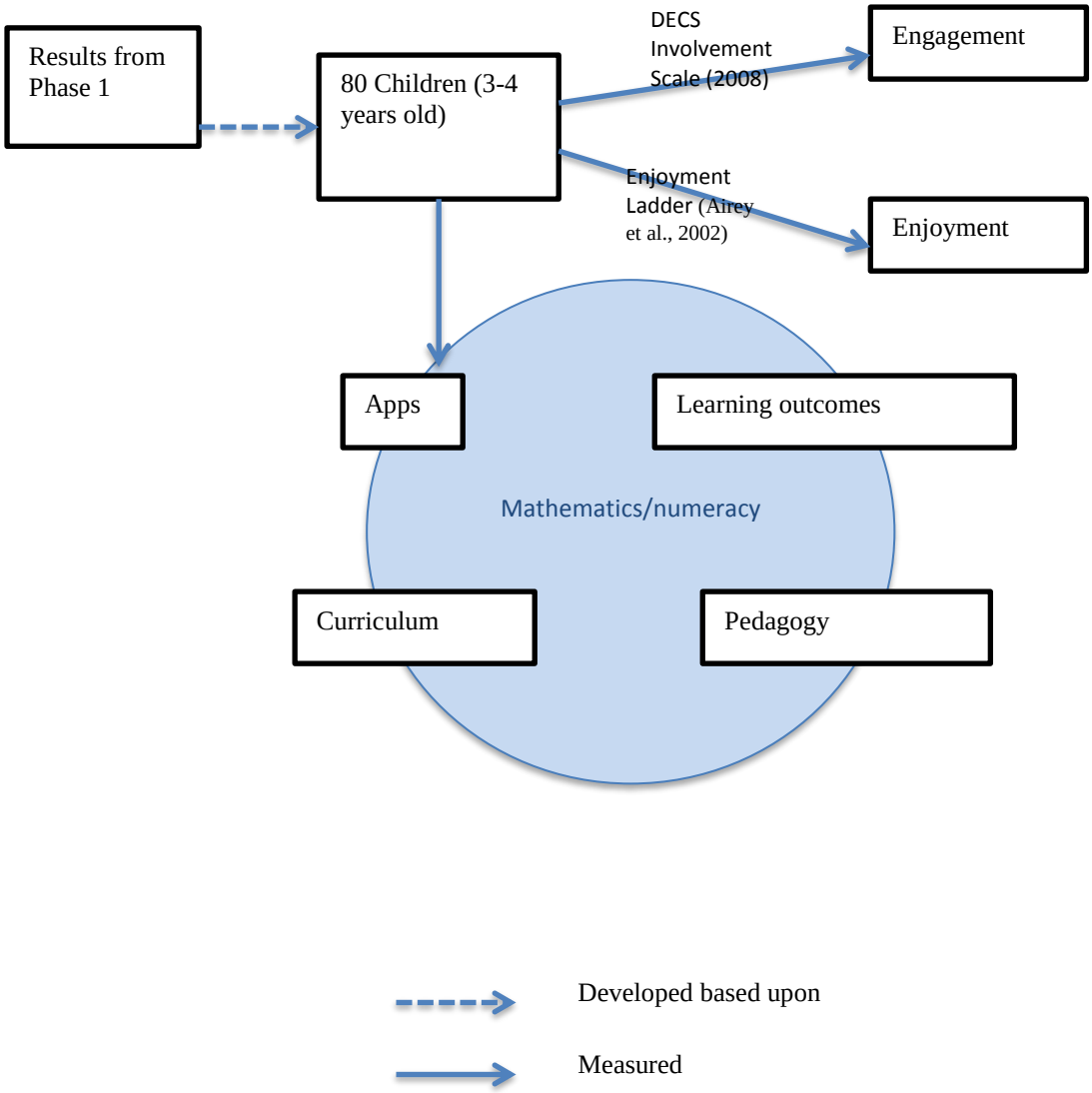

Figure 3.4. Child play phase.

An early childhood numeracy measurement tool was used to analyse children's participation and their numeracy understandings. Pre- and post-tests of children's numeracy scores recorded varying exposure to digital technology (iPads), and using an early childhood-friendly numeracy instrument (see Appendix O) based on a measurement tool from Ramani and Siegler's study (2011), with reliability and validity tested within that study. Children's engagement was measured using an observation procedure described in the Involvement Scale (see Appendix M). Observation has been used as a 'fundamental basis of all research

methods' in the social and behavioural sciences (Denzin & Lincoln, 2011). Denzin and Lincoln (2011) further stated that it is possible to conduct observations in settings that are a natural loci of those activities that may be the result of a controlled experiment. Observations allow the researcher to record information as it happens, as well as taking note of unusual aspects that may impact the research (Kervin et al., 2016, p. 76). Therefore, in this study, semi-structured field observation was used to collect information about children's activities within a child care setting. Enjoyment was measured pre- and post-exposure to the digital technology. An enjoyment measurement instrument was designed based on the measurement scale from the study of Airey's et al. (2002), in which reliability and validity had been tested.

3.3 Research Phases

The three phases of data collection within the present study are described in this section.

3.3.1 Phase 1 –Surveys

3.3.1.1 Pilot study for surveys

Participants

Five child care educators (4 females and 1 male), and five 3-4 year old children's parents (3 females and 2 male) participated in the pilot study. All the five educators were working full time in child care centres.

Instruments

The pilot survey for educators (see Appendix G) and parents (see Appendix H) was designed based upon research by Chen and Chang (2006), Fogarty et al. (2002), Funk et al. (2009) and Li (2006). The pilot study was conducted to test and refine the research instruments to ensure participant understanding.

Procedures

Upon ethics approval from the University of South Australia Human Ethics Committee, information letters and consent forms were handed or emailed to the child care educators and parents. Consent was obtained from all parties (see Appendix C and Appendix D). The pilot study was conducted in February 2012, taking place over a period of three weeks.

The five parents and five educator participants were asked to carefully read the survey instrument and assess its ease of understanding. Minor changes were made to the surveys. See Appendix A and I for pilot and educator surveys, as well as Appendix B and J for pilot and parent surveys. The primary alteration was to provide participants with a list of possible digital technologies to choose from, rather than asking them to list them.

3.3.1.2 Survey for the 3-4 year old children's parents

Participants

One parent of each participating child completed a survey, resulting in 80 parents. Of the 80 parents, 59 (73.7%) were female, and 21 (26.3%) were males. There were 40 parents from South Australia and 40 parents from the Northern Territory.

Occasionally, an individual failed to respond to a specific item, which accounts for minor variations in *N* in data tables in Chapter 4.

Instruments

The survey consisted of three major sections. Section One collected demographics of the participants. The participants were asked to provide their gender, age, all of their children's names, age/s and gender/s, their residential postcode, their highest qualification (*primary school, high school, certificate/diploma, bachelor, postgraduate),* primary spoken language spoken at home, total household annual income range (*below $10,000, $10,000-19,999, $20,000-$29,999, $30,000-$39,999, $40,000-$49,999, $50,000-$59,999, $60,000-$69,999, $70,000-$79,999, $80,000-$89,999, $90,000-$99,999, $100,000-$149,999, Above $150,000),* and their skills in using digital technologies, as listed below.

As all the participants in the survey were required to be over 18 years old, the age groups started from 18 years. As parents of 3-4 year old children are seldom over 51 years old, age was divided into 8 groups (*18-20 years, 21-25 years, 26-30 years, 31-35 years, 36-40 years, 41-45 years, 46-50 years* and *over 51 years).*

Before questions concerning their attitudes towards digital technologies, parents were asked to place themselves into one of the following 5-scale anchor about their skills of using technology: *1 = novice user*, and *5 = expert user.* Combining words and numbers in a 1-to-5

rating scale provides an effective method for measuring the pluses and minuses of everything from people's performance to the relative importance of personal options. The 5-point scale forces a sharper focus than is possible with the popular 1-to-10 scale (Ary et al., 2010). For example, O'Brien, Schmidt and Nguyen (2008) used this method in their study about student technology skill assessment to find out the students' skills of using technology. Kervin et al. (2016, p. 97) describe the use of 5-point scales as a 'useful way of organising, summarising and constructing the allowable responses to a questionnaire item'.

In Section Two, the participants were asked to answer questions about the use of digital technologies in their home. A brief explanation of digital technology was provided at the beginning of this section. Based on the study from Funk et al. (2009), the listed devices were *television, cable television (Foxtel/Austar), DVD player/Blue Ray player, a laptop or desktop computer, video game console like an Xbox, PlayStation, or Wii, handheld video game player like a GameBoy, PSP, or Nintendo DS, Smartboard, Smartphone, video iPod or similar device, Kindle, Nook or similar e-Reader, iPad or similar tablet device,* and *Internet.* The participants were also given an opportunity to list any other devices in an open text box.

The questions revolved around the type of digital technologies children used at home and the frequency of the use of the devices by their 3-4 year old children. Frequencies were categorised based on Funk et al. (2009) categories: *daily, weekly, monthly, at least once a semester, yearly, and has never been used.*

To explore whether parents thought new digital technologies were appropriate for their 3-4 year old children, four methods based on the study of Funk et al. (2009) were provided. These were (a) *watch/play the product for the first couple of minutes to determine if the product is appropriate*, (b) *watch/play the entire program with my child*, (c) *watch/play the entire program by myself before I allow my child to watch/play*, and (d) *apply the ratings system provided by the product (e.g. G, PG, M etc).* An open-ended question allowed the participants an opportunity to discuss their reasons – "*Please indicate the reasons*" within an open text box.

In Section Three, parents' attitudes about the use of digital technologies in early childhood education were investigated.

The parents were asked to rate their agreement to four statements, developed from research by Chen and Chang (2006), Fogarty, et al. (2002), and Li (2006) using the following scale: *strongly disagree*, *disagree*, *unsure*, *agree*, and *strongly agree*. The statements were (a) *in terms of educational value, the implementation of digital technologies into early childhood is an urgent priority,* (b) *I am enthusiastic about the integration of digital technology into my child's child care centre,* (c) *the use of digital technology in child care will replace the role of educators,* and (d) *it is necessary for educators in a child care environment to be trained in the use of digital technologies with young children*.

The parents were also asked to identify the most important reasons for integrating digital technology into child care centres. Four possible reasons based upon the studies of Chen and Chang (2006), Fogarty, et al. (2002), and Li (2006) were provided: (a) *familiarising children with the world of new technologies*, (b) *the curricular and educational benefits*, (c) *the recreational value to the child*, and (d) *parental expectations*. A text box was provided for participants to provide other reasons.

In the following part of this section, parents were asked to provide their views towards the use of digital technology in teaching *literacy, numeracy, science, art and physical education* to 3-4 year old children. A 5-point scale was followed: 1 = *strongly disagree*, 2 = *disagree*, 3 = *unsure*, 4 = *agree*, and 5 = *strongly agree*.

Parents were also asked to provide their views towards the use of digital technology to promote 3-4 year old children's development in the domains of *cognitive development, gross motor skills development, fine motor skills development, language development, and social development*. An explanation for each domain was provided based on the comments from the pilot study (see Section 3.3.1.1). Explanations provided were: cognitive development (*the child's ability to learn and solve problems*), gross motor skills development (*this is the child's ability to use large muscles*), fine motor skills development (*this is the child's ability to use small muscles, specially their hands and fingers*), language development (*this is the child's ability to both understand and use language*), and social development (*the child's ability to interact with others, including helping themselves and self-control*). A 5-point scale was used: 1 = *strongly disagree*, 2 = *disagree*, 3 = *unsure*, 4 = *agree*, and 5 = *strongly agree*.

The final part of this section invited parents to share their attitudes towards the use of iPads or Tablets on a 5-point scale: 1 = *strongly disagree*, 2 = *disagree*, 3 = *unsure*, 4 = *agree*, and 5 = *strongly agree*. An open-ended option allowed the participants an opportunity to discuss their reasons: "*please explain your reasons why"*

Parents were asked about their confidence of knowing what an "App" is: (a) *I am very confident that I know what an App is,* (b) *I have heard what an App is, but I am not totally sure,* and (c) *I don't know what an App is*. If parents chose either (a) or (b), they were asked about their attitudes towards whether the Apps designed for preschool educational purpose were indeed assistive of children's learning on a 5 point scale: 1 = *strongly disagree,* 2 = *disagree,* 3 = *unsure,* 4 = *agree,* and 5 = *strongly agree.*

An open-ended question giving the participants an opportunity for comments was provided at the end of the survey: "Are there any other comments you would like to make?"

Procedures

Upon ethics approval from the University of South Australia Human Research Committee, information letters and consent forms (see Appendix F) were distributed. Survey instruments, in hard copy were handed out to participants and collected later with assistance from child care centres. The survey was conducted in March to April 2012.

Data analysis

Quantitative data was analysed using the Statistical Package for Social Science (SPSS) Version 22 and alpha was set at 0.05. Coding (Wiersma, 2000) was used to develop concepts from the raw qualitative data. Axial coding, open coding, and preliminary coding were used in the process.

The participants' demographic backgrounds, such as the participants' gender, age, their highest qualification and their self-reported skills of using technology, were analysed by using frequencies and descriptive statistics (see Sections 4.2, 4.3, 4.5 and 4.6) . The parents' attitudes toward their children's use of digital technology at home and their attitudes about the use of digital technology in early childhood education were analysed by frequencies and descriptive statistics (see Section 4.4) and compared with the results of children's engagement

and enjoyment in playing the iPad apps by using One-way ANOVA (see Sections 6.8.3, 6.8.4 and 6.8.5). The parents' survey results were also compared with the survey results from site educators via independent samples t-test (See Section 4.8).

A table of the number and percentage of the children's access to different digital technologies was used. Tables were used to present children's access to media devices at home. The means are presented using a 6-point scale: 1 = *daily*, 2 = *weekly*, 3 = *monthly*, 4 = *at least once a semester*, 5 = *yearly*, and 6 = *has never been used*. Tables were also used to present the percentages from the parents' answers about choosing appropriate software and the decision-making process; the percentages of parents' opinions about the use of digital technology in early childhood education; their attitudes towards the use of digital technology for teaching literacy, numeracy, science, art and physical education; and their attitudes towards the use of digital technology for children's development in the domains of cognitive development, gross motor skills development, fine motor skills development, language development and social development opinions. Where appropriate, a repeated measures ANOVA was applied; this measurement was used to 'determine the significance of the difference between or among groups of means' (Kervin et al., 2016, p. 157).

To present parents' opinions towards the use of touch screen devices, their knowledge about Apps, and the usefulness of Apps designed for preschool educational purposes, a figure and tables were used.

The survey involved responding to the rating scale items as well as several open-ended questions. Themes were identified from the seven categories (*social influence*, *performance expectancy*, *effort expectancy*, *facilitating conditions*, *hedonic motivation*, *price value* and *habit*) based upon the Unified Theory of Acceptance and Use of Technology (UTAUT2) (Blackwell et al., 2013; Venkatesh et al., 2012). These became the basis for further investigation in Phase 3.

3.3.1.3 Surveys for child care educators (directors, teachers and carers)

Participants

Forty-nine educators participated in the survey. Of these 49, 4 (8.2%) were male, and 45 (91.8%) were female. Their ages ranged from 18 to 59 years, with 17 (34.7%) from 18-29

years, 15 (30.6%) from 30-39 years, 10 (20.4%) from 40-49 years and 7 (14.3%) from 50-59 years.

Instruments

The survey for educators (see Appendix I) was the same as the parental survey except where indicated below. As all the participants in the survey were required to be over 18 years, the age groups started from 18 years. As educators are seldom over 60 years old, the age groups were divided into 5 groups: *18-29 years, 30-39 years, 40-49 years, 50-59 years,* and *over 60 years.* Educators were asked to enter the length of time they had worked in their current child care centre and state their job title. They were also asked to state their highest qualification from *high school, certificate, diploma, bachelor* or *postgraduate.* Section Two was the same as the parental study, except that children's digital technology use focused on the children's time in care rather than home.

In Section Three, there were two differences between the parental survey and the educators' survey. Firstly, educators were asked three different questions in relation to five statements about the integration of digital technologies. These statements were: (a) *the potential use of digital play enhances the educator's ability to teach*. (b) *funding is sufficient to incorporate digital play into my child care centre*, and (c) *in the next five years my child care centre will have integrated more digital play devices than it already possesses*. Secondly, educators were also asked about in-service training for early childhood educators in the use of digital play from four categories: *mandatory and done annually*, *mandatory and done when new digital play is introduced, optional for staff,* and *not necessary*.

Procedures

The procedure for the educators' survey was the same as the parental survey. See Appendix E for educator information letters and consent forms.

Data analysis

The data analysis for the educators' survey was the same as the parental survey.

3.3.2 Phase 2 – App Review

3.3.2.1 Introduction

From the results of parents' and educators' opinions towards the use of Apps in teaching literacy, numeracy, science, art and PE, it was found that most participants from both groups agreed that Apps can be used to teach numeracy more so than other curriculum areas. Within the literature review (see Section 2.7.2) it was identified that Apple's iPad is the most commonly owned and used tablet device within Australia. Therefore, 50 Apps were chosen for review from the Game Centre on the Apple website in the area of early childhood numeracy education.

3.3.2.2 Instruments

There were two instruments used in this section: Gestural Interface App Rating Scale (GIARS) (see Appendix K) and the Math App Appraisal Scale (MAAS) (see Appendix L).

Based upon Haugland's Scale (1997), GIARS (Geng & Disney, 2015) was designed to identify the Apps' quality in regards to 3-4 year old children's developmental appropriateness. All 50 Apps were measured in 9 areas in GIARS: (1) age appropriateness, (2) contextual environment, (3) seamlessness, (4) scaffolding, (5) no touch left behind (6) the autonomy of a gesture, (7) non-violence, (8) process orientation, and (9) real world model.

In the area of: (1) age appropriateness, there were two categories: "realistic concepts" and "appropriate methods"; (2) contextual environment there were three categories: "minimal interface elements for content", "sequence of learning present", and "a clear beginning; (3) seamlessness there were four categories: "responds to every contact", "transitions fluid", "single finger flick movements" and "no time-based gestures"; (4) scaffolding there were four categories: "appropriate action prompting", "functionality", "intentional user input" and "reversible actions"; (5) no touch left behind there was only one category: "precise selection of content"; (6) anatomy of a gesture there were two categories: "gestures are minimal and immediately clear", and "clear feedback"; (7) non-violence there were two categories: "App is free of violent characters and actions" and "App models positive social values"; (8) process orientation there were three categories: "discover learning, not skill drilling", "intrinsic motivation", and "process engages, product secondary"; (9) real world model there were five

categories: “accurate information”, “advertising is minimal or not apparent”, “concrete representations”, “objects function” and “simple, reliable model”. Each category in each area was rated a scale: *1 = met (all categories met), 0.5 = partially met (at least one category missing and at least one category present),* and *0 = not met (no categories met).*

Based upon the TPACK model (see Section 2.2), MAAS was designed by Handal et al (2014) to appraise numeracy Apps. All 50 Apps were measured in four areas in MAAS: (1) task structure, (2) cognitive involvement, (3) general pedagogical issues, and (4) operation issues. In the (1) task structure, there were three sections: (1) explorative Apps, (2) productive Apps, and (3) instructive Apps. Under each section, there were five items. The user of the MAAS was asked to circle any of the roles of the three sections. The user was also allowed to choose a combination where roles overlap. The user identified task structure to determine the primary role of the Apps.

In Section 1 (explorative Apps), five statements were used: *App closely mirrors a model or real-life situation; students can enter their own data and observe change in the model; exploration is guided within a predetermined learning discovery framework; tasks are goal oriented driving student interest and curiosity* and; *there are elements of ambiguity and uncertainty fostering personal investigation.* A four point scale was used in this section: *always, to some extent, never* and *not applicable.*

In Section 2 (Productivity Apps), five statements were also used: *App lets students to creatively come up with their own design and/or concept; App allows representing maths content by linking symbolic, numerical and graphical data; students are guided in creating their own content/understandings; students can represent or present maths content using a variety of different tools (e.g., audio/video recording, measuring devices, etc);* and *App tools are intuitive and easy to use.* A four point scale was used in this section: *always, to some extent, never* and *not applicable*.

In Section 3 (instructive Apps), five statements were used: *App contains a variety of different activities/exercises; appropriate feedback is provided to students; activities/exercises cater for a range of student ability levels; content is meaningful, fostering engagement and rich problem solving;* and *App contains activities/exercises that are graded and summary data is*

provided. A four point scale was used in this section: *always, to some extent, never* and *not applicable*.

In "cognitive involvement", the user was asked to check on the options for 6 items: *remembering, understanding, applying, analysing, evaluating* and *creating* on a four point scale: *always, to some extent, never* and *not applicable*.

In "general pedagogical issues", the user was also asked to use the four point scale (*always, to some extent, never* and *not applicable)* to check against the following 10 statements about the App: *permits students to pose their own problems; allows for differentiation through sequentially designed degrees of difficulty; gives students control over their learning; delivers content in an appealing and motivating way according to the age group; provides meaningful teaching and learning guidelines; integrates maths with content from other Key Learning Areas; allows students to collect and record their own data; shows a reading level appropriate to the student's level; saves and keeps students' work;* and *provides opportunities for collaboration.*

In "operational issues", the user was asked to use the four point scale (*always, to some extent, never* and *not applicable*) to check against the following 10 statements about the App: *has an intuitive and user friendly navigation; contains helpful technical instructions to the user and/or a help function; lets students alter its settings to customise the app to their needs; allows file sharing, streaming of content and/or online communications; is flexible permitting students to move in different directions; has a supporting Web page providing additional useful information; easily works with a range of media (audio, video, image, text, animations); can interface with social media tools (e.g., Facebook, wikis, blogs, Twitter, YouTube); presents an uncluttered display which is visually stimulating;* and *permits a student leave at any time and begin where he or she left.*

3.3.2.3 Procedures

Using an Apple iPad2, the researcher opened the App Store and chose 'categories' from the menu options at the bottom of the screen. From the selected choices on the page the researcher selected 'education', then sorted the games by 'most popular'. The researcher then worked from most popular to least popular until 50 Apps (free or paid) were selected; Apps

were chosen if they were aimed at a preschool audience and claimed to promote early childhood numeracy.

Firstly, the researcher evaluated all 50 Apps and identified their primary role (task structure, cognitive engagement, pedagogical and informative Apps) based upon the Maths App Appraisal Scale (MAAS) (Handal, et al, 2014). The first sub-scale (task structure) were divided through three items sets (explorative, productivity and informative).

Upon coding the 50 Apps, the researcher played each App one by one and reviewed them according to the printed GIARS form. Each review took approximately half an hour. Data was then entered into the Statistical Package for Social Science (SPSS) Version 22.

3.3.2.4 Data analysis

The Apps' characteristics according to their rated scores in GIARS and MAAS and their financial cost were investigated. Their detailed scores according to the nine areas across the GIARS and four areas in MAAS were also investigated and compared.

Frequencies and descriptive statistics were used to find the properties of the Apps' developmental appropriateness, cost and their detailed scores in the nine areas across GIARS and four areas across MAAS. Cronbach's alpha was used to determine the internal consistency of rating of the chosen 50 Apps and how closely related the nine areas as a group (see Section 5.3).

Means and standard deviations were presented using tables and/or figures for each. Apps were reviewed by ratings across the nine areas in GIARS and four areas in MAAS and thus it was of value to examine for differences across areas in average ratings. Ratings within each one were averaged, and analyses were performed upon average. Relationships among the average of the nine areas in GIARS and four areas in MAAS were then investigated. Correlation tables were used to find the relationships amongst them.

Means of the ratings of the Apps in 9 areas in GIARS, from highest to lowest, using a 3-point scale anchored: *1 = met, 0.5 = partially met,* and *0 = not met*. A repeated measures ANOVA on the means of the ratings were used in each section to test significance.

The GIARS also involved responding to the rating scale items as well as several open-ended comments from the researcher. Eleven factors in the ratings in GIARS were also noted based on researcher comments. Themes were identified and these became the basis for classifications for the factors.

The relationship between the developmentally appropriate Apps and not developmentally appropriate Apps, based on the ratings in GIARS, was also investigated.

Five Apps were chosen from the top-rated Apps and their total scores and individual ratings in the GIARS were investigated. Further investigations on these Apps, which were used in the site observations in Phase 3, were examined in detail with the reports from the children's engagement, and enjoyment in playing the Apps. Upon the children's use of the iPad, one of the Apps was not deemed appropriate and was subsequently swapped for the next highest scoring App. The issue arose with the App's inability to reset to the mathematical ability of the child using it, hence inappropriate for a large group setting.

3.3.3 Phase 3 – Child Play Phase

Young children can learn from books, television, touch screen, and computers, as these can provide a specific form of transference of learning from a 2D source to a 3D object response (Barr, 2010; Durkin & Blades, 2009). The use of 3 and 4 year old children in Phase 3 was based upon: a) there are limited studies on the use of digital play in Australian early childhood settings, b) children younger than 3 years old learn through their bodies – their eyes, ears, mouths, hands and legs – and that the developmental skills these children are learning to master are crawling, walking, talking and making friends (Haugland, 2000) and (c) that screen time is not recommended for children 2 years and under (AAP, 2011). There were three sections in children's playing phase: numeracy measurement, engagement measurement and enjoyment measurement.

3.3.3.1 Participants

Eighty children participated in the children's playing phase, 44 (55%) were male, and 36 (45%) were female. Forty (50%) children were from South Australia, and forty (50%) were from the Northern Territory. The age range was from 36 months (above 3 years) to 59 months

(under 5 years old). Children were classified as 3-4 years age group (43.7%), and 4-5 years age group (56.3%).

Of the 80 children, 12 children (15%) were attending child care centre full time (10 sessions per week) and 68 children (85%) were attending child care centre between 4 sessions to 8 sessions.

3.3.3.2 Instruments

Instruments for numeracy measurement

The numeracy measurement was based upon numeracy outcomes arising from the Apps Review in Phase 2. The numerical domain was selected by analysing which numerical concepts were most prevalent within the highest scoring apps. This measurement was used to analyse children's numeracy understandings. Pre- and post-testing of the numeracy measurement was used, varying exposure to the digital play tool using an 'early childhood friendly' instrument based on a measurement tool from Ramani and Siegler's (2011).

A pre- and post-test sheet for the Numeracy Scale (see Appendix O) was used. The instrument was developed based upon measurement tools from Ramani and Siegler's (2011) and Segal's (2011) studies, with reliability and validity having been tested in the study. The measures adapt a game format which capitalises on children's interest in play and enhances their motivation and cooperation.

There were five parts in the numeracy measurement: a) *numerical identification*, b) *counting*, c) *arithmetic problems*, d) *shape identification*, and e) *patterns*. In numerical identification, the cards with numbers (1 to 10) were shown to the students and the script was used: "*in this game, I will hold up a number card, and I would like you to tell me which number it is"*. In counting, children were asked to count as high as they can, and the script for counting is: "*this is the second game, can you count from 1-10? Ready Go!"*. If they completed that task, the child was prompted: "*wow, that was great counting, can you count to 100! Ready? Go!"*. In arithmetic problems, the researcher gave the child rubber animal counters, with the script used: "*suppose you have N animals and I give you M more; how many animals would you have then?*", four arithmetic problems were used: *2 + 1, 2 + 2, 4 + 2* and *2 + 3*. In shape identification, 10 shapes were used and the script was: "*I have some shape cards. Can you tell*

me what shape this is?". The 10 shapes were a circle, triangle, square, rectangle, diamond, pentagon, hexagon, octagon, oval and star (see Figure 3.5).



Figure 3.5. Shape identification.

In patterning, the researcher presented the child with two patterns using the plastic animal counters, the script: "*I have a pattern, red, blue, red…can you tell me what comes next?*" and "*I have another pattern, green, red, blue, green, red…can you tell me what comes next?*" was used. The following two patterns were used (see Figure 3.6).

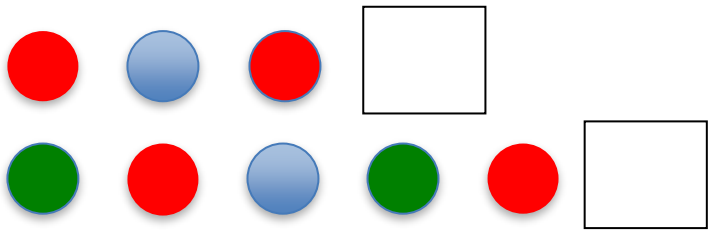

Figure 3.6. Pattern.

There was no form of interference, encouragement or disturbance from the researcher other than the script during the tests.

Instruments for engagement measurement

Engagement was measured based upon the observation procedure described in the Involvement Scale (see Appendix M). Observation has been used as a "fundamental basis of all research methods" in the social and behavioural science (Denzin & Lincoln, 2005).

The tool, Laevers Child Involvement Scale, used in the publication *"Assessing for learning and development in the early years using observation scales: Reflect Respect Relate*" from the Department of Education and Children Services (DECS, 2008, p. 81) was used to analyse the children's engagement (also classified as involvement) whilst playing with the iPad games. Ebbeck et al. (2012) effectively used the Laevers Child Involvement Scale to assess the strengths and weaknesses of Singaporean early childhood curriculum by measuring children's engagement within programs. The Involvement Scale describes nine signals that a child participating in an activity was indeed 'involved', they include: (1) *concentration, (2) energy, (3) complexity/creativity, (4) facial expression and posture (non-verbals), (5) persistence, (6) precision, (7) reaction time, (8) verbal utterances/language, and (9) satisfaction* (see Appendix M). Concentration, energy, complexity/creativity and persistence are four essential signals that must be present for sustained and intense involvement. Within each signal were descriptors that identified the characteristics of the participants, for example, the indicators for concentration included: (1) *the attention of a child was directed towards the activity* (2) *only intense stimuli reaches/distracts* and (3) *eye movements were fixed on the activity (do not wander around environment)*. Each signal had indicators which must be observed and assist in ranking the signal as *low (l), medium (m)* or *high (h)* during observations.

The rating within each signal was designated as l, m or h and the aggregation of those signals ranked the observation on a scale, being: (1) *scale rate 1 – no activity*, (2) *scale rate 2 – frequent interrupted activity*, (3) *scale rate 3 – more or less maintained activity*, (4) *scale rate 4 – activity with intense moments* and (5) *scale rate 5 – sustained intense activity*. The scale rate also had descriptors to assist in grading, for example scale rate 1-no activity, was where the child showed the indicators of: (1) *no concentration: staring daydreaming* (2) *an absent, passive attitude* (3) *no goal-orientated activity, aimless actions, not producing anything* (4) *no signs of exploration and interest*, and (5) *not taking anything in, very little mental activity*.

Instruments for enjoyment measurement

Enjoyment was measured pre- and post-exposure to the digital play tool. An enjoyment measurement instrument was designed based upon the measurement scale from Airey et al. (2002) study. Reliability and validity have been tested.

The measurement included the following instruments:

- Digital camera,
- Card and glue,
- Sticky ladder rating scale: Cardboard (white and red). Cut out a red cardboard ladder and stick it onto a white back ground (Airey et al., 2002),
- Velcro dots, and
- Sticky ladder rating chart (see Appendix N).

Airey et al. (2002) state that 'due to a lack of suitable rating scales' for use with children and digital technologies, a novel rating scale has been devised. This scale was based on the idea of a tangible object that children could physically manipulate to express their views. Rather than pointing to pictures on a scale, children respond by sticking a range of items onto a small ladder with Velcro. For the purposes of this study the response items consisted of five images of typical children's toys and games. The five pictures (iPad, Painting, Playdough, Reading, and Xylophone) were pre-made and used in the ladder rating chart in both pre and post-test (see Appendix N). The sticky ladder rating chart was only visible by each child during their turn and other children could not directly see the participating child's answers. The benefit of such a scale was the lack of requirement for complex language skills or instructions. Children as young as three years had been able to comprehend the task and complete it easily (Read, 2008).

3.3.3.3 Procedure

Upon ethics approval from the University of South Australia Human Research Committee, letters to the participants' parents and service directors were distributed (see Appendix C and Appendix D). In the Northern Territory, an email had also been sent to the manager of Catholic Education for approval.

The directors and educators were asked to assist in the children's playing phase. The children's playing phase (the numeracy measurement, engagement measurement, and enjoyment measurement) were conducted in April to May 2012 in South Australia and June to July 2012 in the Northern Territory, taking place over a period of four weeks in each service. The researcher introduced himself to the children and informed them of their research

rights and the study in language they could understand.

Procedure for numeracy measurement

The numeracy measurement was undertaken in Week 1 (pre-test) and Week 4 (post-test) in the four-week data collection period in both South Australia and the Northern Territory.

The researcher asked each child to sit with him one-on-one to limit distractions. The child was invited to play a game using the protocol sheet to ensure consistency. The researcher took turns with the child throughout the game and recorded the child's responses on a score sheet. Qualitative comments were noted if considered relevant to the observation. Although the researcher participated in the game, the protocol ensured that the researcher did not supply cues that could affect a child's response.

There were five parts in the numeracy measurement: a) numerical identification, b) counting, c) arithmetic problems, d) shape identification and, e) patterns.

Procedure for engagement measurement

The engagement measurement was undertaken in Week 2 and Week 3 in the four-week data collection period in both South Australia and the Northern Territory.

The researcher asked the educators for an appropriate space to fit within the routines and play environment of the service. A naturalistic setting outside or inside was provided, usually with tables and chairs but also on carpeted areas. Once positioned and children were playing, if there were any arguments over the use of the iPads, a time allocation chart was used to determine who gets to use the iPads and for how long. In terms of questions asked by children, the researcher only assisted children if asked questions relating to operation of the iPad, for example, how to turn the iPad on. If the children asked curricula question the researcher replied: "*I'm not sure, what do you think?*"

All children were observed during their first use of the iPad, and five times after for a total of six observations. Each observation was two minutes in duration, and started at any time whilst the child was using the iPad. If the child left the iPad during the two-minute observation period, the researcher continued to observe the child in case they returned to the iPad. After the two-minute observation, the researcher took time to make notes and fill out the

rating scale. Each observation required a separate score sheet (see Appendix M) for each child for the six observations.

Procedure for enjoyment measurement

The enjoyment measurement was undertaken in Week 1 (Pre-test) and Week 4 (Post-test) in the four-week data collection period in both South Australia and the Northern Territory.

During the pre-test week, the researcher asked each child to sit with him and he showed the child the ladder and the toy cards and used the following example protocol (see Figure 3.7).

> "This is my toy ladder (point to ladder), it is where I put my favourite toys. Here are my toys (point to toy cards)".
>
> "Can you put the toy you would most enjoy playing with at the top of the ladder"?
>
> If the child does not respond, prompt the question again and explain that the card has sticky Velcro on the back of the card so as to stick to the ladder.
>
> If the child places the first card down then ask:
>
> "Which would be the next toy you would most enjoy playing with"?

Figure 3.7. Protocols example.

This was continued until all the cards had been placed on the ladder. The child was thanked and returned to their regular play routine. The researcher then recorded the child's name and toy ranking on the sticky ladder rating chart (see Appendix N), 1 being the highest card on the ladder to 5 being the lowest.

After exposure to the digital technology used in the study, during the post-test week the same procedure was carried out in week 4.

3.3.3.4 Data Analysis

The participants' demographic background was analysed by using frequencies and descriptives to attain the properties of the participants' gender, age and attendance at child care centres. The findings from children's engagement in playing Apps were reported in Section 6.8. The children's engagement in playing with the Apps was analysed, followed by their numeracy abilities before and after playing the Apps. Paired sample t-tests were run to

compare the means between pre-test and post-results in their numeracy abilities. To avoid the assumption of normal distribution, a Wilcoxon signed-rank test was also conducted. Wilcoxon signed-rank test was again used to compare the means of pre-test and post-test results in each participating child care centre.

At times, when the children were playing with the Apps, there were up to nine other children around and interacting with the participants. They were explaining, discussing, watching or distracting participants' play. Therefore, the number of children who were non-participants, but having consent to participate in the study, interacting or observing the child using the iPad were observed and recorded within the Engagement Scale's notes section. The number of children observing participating children's iPad use was characterised by using means and standard deviation. In addition, the researcher's observations of non-participating, yet observing, children's interactions with participating children were coded to identify themes of behaviour, according to the instruction of "Reflect, Respect and Relate" (Department of Education and Children Services, 2008). The qualitative data from the observation were also quantified; as quantitative analysis of qualitative data can be done by coding ethnographic data and looking for emerging pattern (Silverman, 2014).

The children's enjoyment scales before and after playing with the Apps were analysed by running paired sample t-tests to compare the means between pre- and post-test results for the five toys identified in the children's lists of preferred play toys.

Finally, other factors that influence children's playing from the observation notes and children's parents' comments were investigated. These factors were generated into fifteen themes by the researcher through observation and the frequencies of the factors were presented by the means and standard deviations for each factor.

The children's access to digital play at home and child care centres was investigated with children's engagement and enjoyment measurement. Frequencies and descriptives were used to compare different groups of children's access. Parents', directors' and educators' attitudes towards the use of digital play in early childhood education were also investigated with the children's engagement and enjoyment measures.

3.4 Conclusion

This chapter has presented the research methodology and design of the current study. The study included three phases: survey, Apps review and child play phase. In Phase 1, five parents, five directors and five educators participated in the pilot study. Then 80 parents and 49 child care educators participated in the survey. Fifty Apps were reviewed in Phase 2. In Phase 3, 80 children (40 from South Australia, and 40 from the Northern Territory) participated in the child play phase. In the Phase 3, children's numeracy skills, engagement and enjoyment in playing with the iPad were measured and compared. The site survey results were also investigated, analysing children's engagement and enjoyment whilst playing with the iPad. The results from these phases will be discussed in Chapters 4 to 6.

Chapter IV: Early Childhood Parents' and Educators' Use and Perceptions of Digital Technology

4.1 Introduction

This chapter presents the findings of the surveys about early childhood educators' and parental attitudes towards the use of digital technology in the home, child care service and broadly within early childhood education. The chapter reports the following sections of findings from the surveys conducted in March 2012, including: (a) demographic characteristics of parents and educators; (b) participants' parents' attitudes or opinions towards use of digital technology in early childhood education, (c) educators' attitudes or opinions towards use of digital technology in early childhood education, and (d) differences and similarities between parents' and educators' attitudes or opinions towards use of digital technology in early childhood education. It then highlights the key points to be discussed further in Chapter 7.

4.2 Participating Children's Parents

Eighty parents of 3-4 year old children completed a survey, this being one survey per child who participated in Phase 3. This section reports the parents' gender, age, highest qualification, technology skills level, family annual household income and the number of children in the family.

Of the 80 parents, 59 (73.8%) were female and 21 (26.3%) were male. Their age range was between 26 to 50 years, with 7.5% being 26-30 years old, 28.8% being 31-35 years old, 51.3% being 36-40 years old, and 10% being above 41 years old. Therefore the predominant age range for parents within the study was between 31 to 40 years old (90.1%).

The parents' highest qualifications ranged from high school to post graduate, with 12.5% obtaining high school, 26.3% obtaining certificate-diploma, 43.8% obtaining bachelor and 17.5% obtaining post-graduate. The level of education of this sample is not typical of the Australian population, as according to the Australian Bureau of Statistics (2015), whilst 'nearly six out of 10 Australians have qualifications, only a quarter have a degree'. This is a potential limitation of the study and will be addressed in Chapter 8. Both of the child care

centres were located in middle socio-economic areas in both state and territory, and more than half of the parents had a tertiary education degree, which represented a group of well-educated participants.

All parents reported using digital technology. According to their self-report from a 5-point scale (1 = novice user, and 5 = expert user), 3 parents (3.8%) rated themselves 2, 42 (52.5%) parents rated themselves 3, 20 parents (25.0%) rated themselves 4, and 15 parents (18.8%) rated themselves 5 (see Figure 4.1). The mean of the 80 parents was 3.49 (see Table 4.1). This variable was referred as parents' skills of using digital technology (PST). This finding indicates that parents in their home are using digital technology and that they are confident in using this technology.

Table 4.1

Means and SD of Parents' Skills of Using Digital Technology

	Mean	*SD*	*N*
Parents' self-rated skills of using digital technology	3.49	.84	80

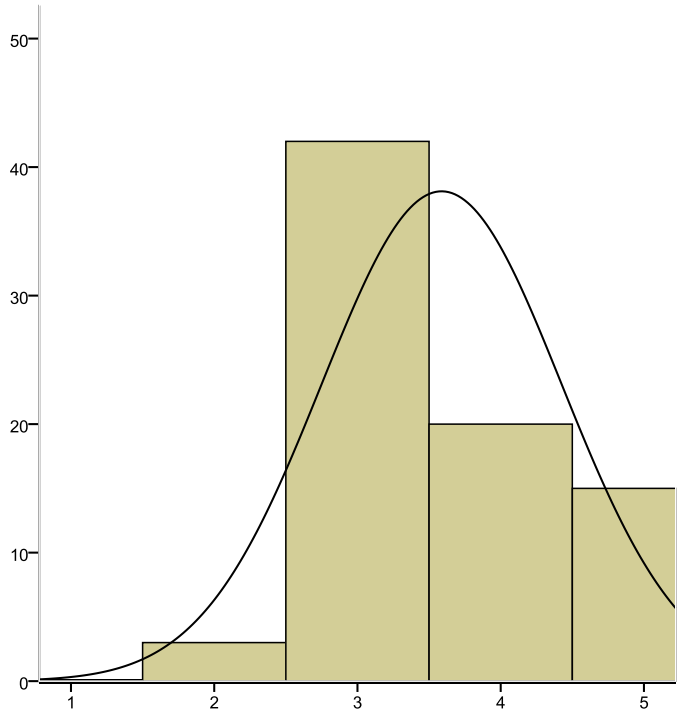

Figure 4.1. Parents' self-reported skills of using technology.

Of the 80 families, 78 (97.5%) reported English as the primary language spoken at home, and 2 (2.5%) reported Filipino.

Family annual household incomes in this study conducted in 2012 ranged between $40,000 to above $150,000, with 49.9% below $100,000, 38.8% reporting $100,000-$149,000, and 16.3% reporting above $150,000 (see Figure 4.2). The median income of Australian households who use child care settings was $117, 936 in 2013-2014 (Australian Bureau of Statistics, 2014). This demonstrates that at least half of the families within this survey were below the median. There was also a broad range of incomes with the potential to impact consumer spending on digital technologies.

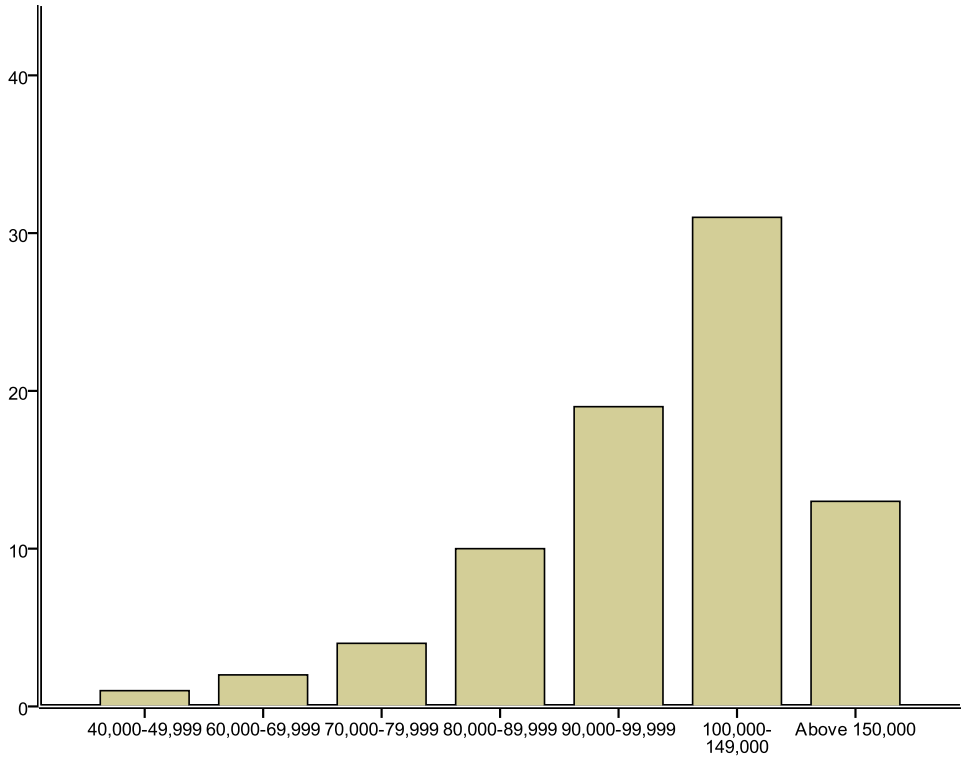

Figure 4.2. Participating families' annual household incomes.

Of the 80 participating children, 35 (43.7%) were only children and 45 (56.3%) had siblings. Twenty-nine (36.3%) children had 1 sibling, and 16 (20%) had 2 or 3 siblings.

4.3 Digital Technology Accessed Within the Home

This section reports children's access to digital technologies within the home environment and what decision-making processes go into the selection of digital technology for children's viewing and technology engagement.

Parents were asked to select from a list of digital technologies including television, cable television (Foxtel/Austar), DVD player/Blue ray player, computer (laptop or desktop), video games (e.g., Xbox, Playstation, or Wii), handheld video game player (e.g., GameBoy, PSP or Nintendo DS), Smartboard, Smartphone, Video iPod or similar device, Kindle, Nook or similar e-Reader, iPad or similar tablet device, and the Internet. The 80 parents were asked to choose whether their children had access to these digital technologies within the home and

how often they accessed these devices. Table 4.2 presents the number and percentage of the children who had access to different types of digital technologies in the home. Two participant's added "Leapster explorer" in the field of "other devices"; as this is a hand-held device, it was categorised in "handheld video game player. The most predominantly accessed digital technology by children within the home was "television" (97.5%) and "DVD player/Blue ray player" (97.5%). The least accessed devices were "Smartboard" (1.3%) and "Kindle, Nook or similar e-Reader" (3.8%).

Table 4.2

Children's Access to Digital Technologies at Home (Number and Percentage of Children Who Had Access)

	n	percentage
Television	78	97.5
DVD player/Blue ray player	78	97.5
Computer (laptop or desktop)	64	80
Internet	62	77.5
Smartphone	55	68.8
Video games (e.g., Xbox, Playstation, or Wii)	37	46.3
Video iPod or similar device	25	31.3
Handheld video game player (e.g., GameBoy, PSP or Nintendo DS)	24	30
IPad or similar tablet device	23	28.8
Cable television (Foxtel/Austar)	16	20
Kindle, Nook or similar e-Reader	3	3.8
Smartboard	1	1.3

Note. The number and percentages are presented from the highest to lowest.

Of the digital technologies accessed by children, parents were asked how regularly the devices were used by the child within the home environment, choosing from a 6 point scale (1 = daily, 2 = weekly, 3 = monthly, 4 = at least once a semester, 5 = yearly, and 6 = has never been used). Table 4.3 presents the means and standard deviations for the children's use of digital technologies in the home. The means show that "television" and "DVD player/Blue

ray player" were the most frequently used digital technologies, whilst "Smartboard" and "Kindle, Nook or similar e-Reader" were used least. A repeated measures ANOVA was applied across the 12 frequencies. A significant effect was evident (see Table 4.3).

Table 4.3

Children's Use of Accessed Digital Technologies at Home (Means)

	Mean	*SD*	*N*
Television	1.36	0.78	80
DVD player/Blue ray player	2.39	1.09	80
Computer (laptop or desktop)	3.76	1.57	80
Internet	4.24	1.60	80
Smartphone	4.38	1.65	80
Video games (e.g., Xbox, Playstation, or Wii)	4.85	1.61	80
Video iPod or similar device	5.01	1.75	80
IPad or similar tablet device	5.09	1.67	80
Cable television (Foxtel/Austar)	5.11	1.81	80
Handheld video game player (e.g., GameBoy, PSP or Nintendo DS)	5.25	1.41	80
Smartboard	5.95	0.45	80
Kindle, Nook or similar e-Reader	5.98	0.22	80

Note. (a) The means were presented from lowest to highest, using a 6 point scale anchored (1 = daily, 2 = weekly, 3 = monthly, 4 = at least once a semester, 5 = yearly, and 6 = has never been used). (b) A repeated measures ANOVA on the above means revealed a significant effect, F (11, 869) = 87.10, $p < .01$. This suggests that all the digital technologies were discriminating effectively between the items.

Table 4.4 shows the percentages of children's use of digital technologies within the home. The majority of children who had access to "television" used it on a daily basis (75.0%). Similarly, children used "DVD player/Blue ray player" on a weekly basis (66.3%). Conversely, a range of devices accessible to children within the home that were rarely used included, video iPod or similar device, iPad or similar tablet device, cable television (Foxtel/Austar), Smartboard and "Kindle, Nook or similar e-Reader.

Table 4.4

Children's Use of Accessed Digital Technologies at Home (Percentages)

	1	2	3	4	5	6
Television	75.0	17.5	6.3	0	0	1.3
DVD player/Blue ray player	7.5	66.3	18.8	1.3	0	6.3
Computer (laptop or desktop)	1.3	23.8	30.0	15.0	2.5	27.5
Internet	1.3	15.0	26.3	12.5	6.3	38.8
Smartphone	3.8	12.5	20.0	12.5	8.8	42.5
Video games (e.g., Xbox, Playstation, or Wii)	0	16.3	11.3	5.0	6.3	61.3
Video iPod or similar device	3.8	16.3	5.0	0	0	75.0
IPad or similar tablet device	5.0	11.3	3.8	5.0	0	75.0
Cable television (Foxtel/Austar)	10.0	8.8	1.3	0	0	80.0
Handheld video game player (e.g., GameBoy, PSP or Nintendo DS)	0	11.3	6.3	2.5	6.3	73.8
Smartboard	0	1.3	0	0	0	98.8
Kindle, Nook or similar e-Reader	0	0	0	1.3	0	98.8

Note. (a) All above figures represent percentages within each item. (b) 1 = daily, 2 = weekly, 3 = monthly, 4 = at least once a semester, 5 = yearly, and 6 = has never been used.

It was found that over two-thirds of all children had access to the following four digital technologies: television, DVD player/Blue ray player, computer and smartphone, and approximately half (46.3%) had access to video games. Less than one-third of children had access to (a) video iPod or similar devices, (b) handheld video game player (e.g., GameBoy, PSP or Nintendo DS), (c) iPad or similar tablet device, (d) cable television (Foxtel/Austar), (e) Kindle, Nook or similar e-Reader, and (f) Smartboard.

These results indicate that the main digital technologies accessed and used within home settings continue to be passive, one-way interactional screens, such as TV and DVD player. Hand-held devices were not popularly used by children within their homes. The hardware used within Phase 3, being iPad, was only accessed by fewer than 30% of children in the

home, and of those children 75% had not used the device. This indicates that within Phase 3, iPad would have been a novel experience for children (see Chapter 6).

Household income played a significant role in the children's frequency of access to Smartphone and iPad. The children in the highest income families had the most frequent access to Smartphone (F = 2.84, p = 0.02) and iPad (F = 3.14, p = 0.02). This finding suggests that there is potential for a digital divide between families that can afford digital technologies and those that cannot.

Parents were asked how they decided if a new digital technology (e.g. computer games, television programs, DVDs etc.) was appropriate for their child(ren). Five multiple choices were provided: (a) Watch/technology the product for the first couple of minutes to determine if the product is appropriate, (b) Watch/technology the entire program with their child(ren), (c) Watch/technology the entire program by themselves before they allow their child(ren) to watch/technology, (d) Apply the ratings system provided by the product (e.g. G, PG, M etc.), and (e) Other e.g. product advertising.

Table 4.5 shows the percentages for parents' decision-making procedures. Most parents chose either "Watch/technology the product for the first couple of minutes to determine if the product is appropriate" or "Apply the ratings system provided by the product (e.g. G, PG, M etc.)" This indicates that parents trust the Australian Classification Board classification systems, which suggests that parents expect that the product is doing what it states in terms of educational content/value and if it does not, parents could potentially be unaware of the implications of poor-quality educational outcomes from poorly-designed products.

Table 4.5

Parents' Decision-making Procedure for Using New Digital Technologies at Home (Percentages)

	Yes	No
Watch/technology the product for the first couple of minutes to determine if the product is appropriate	78.8	21.3
Watch/technology the entire program with their child(ren),	17.5	82.5
Watch/technology the entire program by themselves before they allow their child(ren) to watch/technology	7.5	92.5
Apply the ratings system provided by the product (e.g. G, PG, M etc)	82.5	17.5
Other e.g. product advertising	3.8	96.3

4.4 Parent Attitudes towards the use of Digital Technology in Early Childhood Education

This section reports on four primary results: (a) parental attitudes towards digital technology in early childhood, (b) parental attitudes towards digital technology for curricula teaching, (c) parental attitudes towards digital technology for children's development, and (d) parental attitudes towards the use of touch screen devices for preschoolers.

4.4.1 Parental Attitudes towards Digital Technology in Early Childhood

The following questions were used to measure parental attitudes towards the use of digital technology within early childhood settings. This section firstly reports on parents' opinions about the use of digital technology in early childhood education in the following order: (a) parent's view towards digital technology is an urgent priority, (b) parents' view towards digital technologies integration in child care centre, (c) parents' view towards digital technologies replacement of educators, and (d) parents' view towards training of staff.

Table 4.6 shows that parents did not agree that the use of digital technology in child care would replace the role of educators, but they did agree on all the other areas.

Table 4.6

Parents' Opinions about the Use of Digital Technology in Early Childhood Education (Means)

	Mean	SD	N
view towards digital technology is an urgent priority	3.31	1.04	80
view towards digital technologies integration in child care centre	3.53	1.08	80
view towards digital technologies replacement of educators	1.24	0.58	80
view towards training of staff	3.96	0.96	80

Note. The means are presented using a 5 point scale anchored (1= strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree).

Table 4.7 presents the percentages of parents' opinions about the use of digital technology in early childhood education. Most of the parents chose higher than agree in (a) digital technology should be integrated in child care centre (60.1%), and (b) it was necessary for educators in a child care environment to be trained in the use of digital technology with young children (78.8%). Almost all the parents (97.5%) chose either strongly disagree or disagree in response to the use of digital technology in child care would replace the role of educators. This indicates that parents believe digital technology should be integrated into early childhood services, however the urgency of integration is less important than the gradual introduction. Additionally, the results clearly show that parents expect educators to be trained in how to use digital technology effectively with children; but at the same time that the role of digital technology cannot replace the role of an educator; and within an early childhood setting there is an emphasis on the social and emotional well-being of children.

Table 4.7

Parents' Opinions about the Use of Digital Technology in Early Childhood Education (Percentages)

	1	2	3	4	5
view towards digital technology is an urgent priority	2.5	23.8	25.0	37.5	11.3
view towards digital technologies integration in child care centre	5.0	13.8	21.3	43.8	16.3
view towards digital technologies replacement of educators	81.3	16.3	0	2.5	0
view towards training of staff	3.8	3.8	13.8	50.0	28.8

Note. (a) All above figures represent percentages within each item. (b) 1= strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree.

The parents were also asked to provide reasons as to why digital technology should be integrated into child care centres. The four reasons provided were (a) familiarising children with the world of new technologies, (b) the curricular and educational benefits, (c) the recreational value to the child, and (d) parental expectations. Parents were also invited to add other reasons.

Table 4.8 shows that most of the parents thought that "familiarising children with the new technologies" was the primary reason for integrating digital technology into child care centres, followed by the "curricular and educational benefits". These results indicate that parents understand the role of technology in children's future educational and working careers and the importance of early exposure in relation to children's ability to master these tools.

Table 4.8

Parents' Perceptions of Reasons Digital Technology Is Integrated into Child Care

	Yes		No	
	n	percentage	*n*	percentage
familiarising children with the world of new technologies	69	86.3	11	13.7
the curricular and educational benefits	45	56.3	35	43.7
the recreational value to the child	24	30.0	56	70.0
parental expectations	7	8.7	73	91.3

Four of the 80 parents presented additional reasons. Themes were identified from the seven categories (social influence, performance expectancy, effort expectancy, facilitating conditions, hedonic motivation, price value and habit) based upon the Unified Theory of Acceptance and Use of Technology (UTAUT2) (Blackwell et al., 2013; Venkatesh et al., 2012). The number in brackets represents the frequencies of the factors (some comments were categorised into multiple categories).

Category 1: performance expectancy (3)
Category 2: effort expectancy (0)
Category 3: social influence (1)
Category 4: facilitating conditions (0)
Category 5: hedonic motivation (0)
Category 6: price value (0)
Category 7: habit (0)

Three examples from parents include:

Question 13: In your opinion, what are the other important reasons for integrating digital technology into child care centres?
Parent #5: To use the same technology as parents.
Parent #16: Diverse teaching methods.
Parent #40: Sometimes use it as a reward system.

Parent #40 discussed that a reason for using technology with young children was as a reward system, which would indicate that parents believe technology holds a level of enjoyment for their child and the ability to bargain technology use will assist in moderating children's behaviour.

4.4.2 Parental Attitudes towards Digital Technology for Curricula Teaching

This section reports on the parents' attitudes towards the use of digital technology for teaching literacy, numeracy, science, art and physical education from a 5-point scale (1 = strongly disagree, and 5 = strongly agree).

Table 4.9 shows that most parents thought that the use of digital technology could be used to teach literacy, numeracy, science and art, but not physical education.

Table 4.9

Parents' Opinions about the Use of Digital Technology Teaching Literacy, Numeracy, Science, Art and Physical Education (Means)

	Mean	*SD*	*N*
Numeracy/mathematics	4.19	0.73	80
Literacy/language	4.13	0.64	80
Science	3.60	0.84	80
Art	3.45	1.03	80
Physical education	2.30	1.00	80

Note. (a) The means are presented in order, from highest to lowest using a 5 point scale anchored (1= strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree). (b) A repeated measures ANOVA on the above means revealed a significant effect, F (4, 316) = 112.06, $p < .01$.

Table 4.10 shows that most parents agreed that use of digital technology could be used to teach numeracy/mathematics (86.3%), literacy/language (87.6%), science (63.8%) and art (57.6%). It was also noted that more than half the parents (57.5%) did not think use of digital technology could be used in teaching physical education. This result indicates that parents believe digital technology is effective in developing cognitive based skills such as numeracy and literacy whilst adding little value to children's physically based skills. These results can be interpreted that parents have observed learning in this area with their own children or there is a perception (real or otherwise) that digital technology has the potential to develop these

curricula areas. This potentially reflects the implementation of hand-held gestural devices utilising developmentally appropriate physical actions by children.

Table 4.10

Parents' Opinions about the Value of Digital Technology for Teaching Literacy, Numeracy, Science, Art and Physical Education (Percentages)

	1	2	3	4	5
Numeracy/mathematics	0	2.5	11.3	51.3	35.0
Literacy/language	0	1.3	11.3	61.3	26.3
Science	1.3	11.0	25.0	55.0	8.8
Art	5.0	13.8	23.8	46.3	11.3
Physical education	25.0	32.5	31.3	10.0	1.3

Note. (a) All above figures represent percentages within each item. (b) 1= strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree.

4.4.3 Parental Attitudes towards Digital Technology for Children's Development

This section reports parents' attitudes towards the use of digital technology for children's development in the domains of cognitive, gross motor skills, fine motor skills, language and social development.

Table 4.11 shows that the most parents thought that digital technology could be used to support children's cognitive, fine motor and language development. Most parents did not agree that digital technology could be used to support children's social and gross motor development.

Table 4.11

Parents' Attitudes towards the Use of Digital Technology in Developing Children's Cognitive, Gross Motor and Fine Motor Skill, Language, and Social Development (Means)

	Mean	*SD*	*N*
Cognitive development	4.21	0.88	80
Fine motor skills development	3.93	0.90	80
Language development	3.46	0.90	80
Social development	2.45	0.94	80
Gross motor skills development	2.01	0.96	80

Note. (a) The means are presented in order, from highest to lowest using a 5 point scale anchored (1= strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree). (b) A repeated measures ANOVA on the above means revealed a significant effect, F (4, 316) = 142.33, $p < .01$.

Table 4.12 presents the percentages of parents' attitudes towards the use of digital technology in supporting children's development. Most parents agreed that digital technology could be used to support cognitive development (83.8%) and fine motor skills (76.3%), and more than half agreed that it can support language development (58.8%). Most parents did not think digital technology could be used to support children's gross motor skills development (73.8%) and more than half did not think it could support children's social development (57.6%). These results combined with the results from Section 4.3.2 indicate that parents consider digital technology to be primarily a tool for developing children's cognitive skills, such as mathematics and literacy. Therefore, tools associated with digital technology are perceived to have benefits for children's learning associated with the mind. Of particular interest is that only 15.1% of parents believed social development was achievable through the use of digital technology, which links to the perception of digital technology as socially isolating.

Table 4.12

Parents' Attitudes towards the Use of Digital Technology in Developing Children's Cognitive, Gross Motor and Fine Motor Skill, Language, and Social Development (Percentages)

	1	2	3	4	5
Cognitive development	1.3	3.8	11.3	40.0	43.8
Fine motor skills development	2.5	3.8	17.5	51.3	25.0
Language development	2.5	13.8	25.0	52.5	6.3
Social development	13.8	43.8	27.5	13.8	1.3
Gross motor skills development	35.0	38.8	16.3	10.0	0

Note. (a) All above figures represent percentages within each item. (b) 1= strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree.

4.4.4 Parental Attitudes towards the Use of Touch Screen Devices for Preschoolers

This section reports on parents' attitudes towards the use of touch screen devices for preschool aged children. It then presents parents' knowledge about Apps and whether they believe Apps designed for preschool educational purposes are appropriate for preschool aged children.

Most parents thought that the use of touch screen devices were appropriate for preschool age children, *Mean* = 3.55, *SD* = 1.12 (see Figure 4.3).

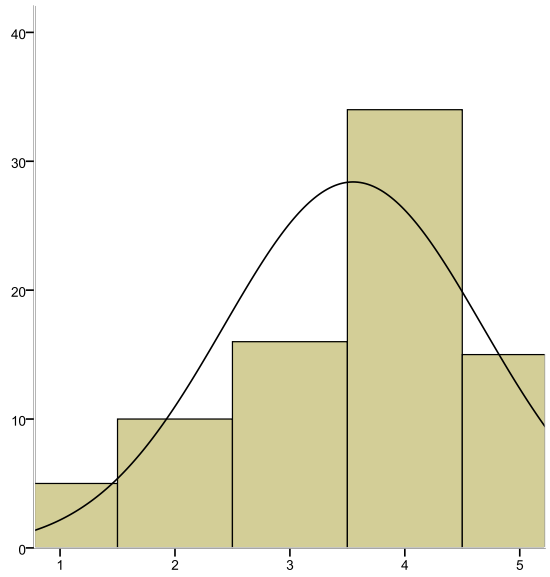

Figure 4.3. Parents' attitudes towards the use of touch screen devices (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree).

Parents were then asked to explain their reasons for why they agreed or disagreed that touch screen devices were appropriate for children aged 3 to 4. Thirty of the 80 parents reported their reasons. Themes were identified from the seven categories based upon UTAUT2. The numbers in the brackets represent the frequencies of the factors (some comments were categorised into multiple categories).

Category 1: performance expectancy (14)

Category 2: effort expectancy (13)

Category 3: social influence (10)

Category 4: facilitating conditions (1)

Category 5: hedonic motivation (4)

Category 6: price value (0)

Category 7: habit (0)

Three examples from parents include:

Question: Do you agree that touch screen devices, such as Apple's iPad, Sony's Tablet S or Samsung's Galaxy Tab are appropriate for use by children aged 3 to 4 years of age? Please explain your reasons why.

Parent #13: They are learning whilst enjoying the activity.
Parent #16: Intuitive interface, large array of educational apps, can select age appropriate apps, engaged learning, discovery element can't be replicated in other teaching easily [sic].
Parent #36: For educational purposes I agree iPads are useful tools as long as the devices are monitored and they have age appropriate apps [sic].

These results indicate that parents are aware of the potential of touch screen interfaces for young children's development (consistent with data from sections 4.3.2 and 4.3.3) and consequently deem touch screens to be an appropriate tool for use with preschool aged children. Many of the comments revolved around the performance expectancy of these devices, highlighted by comments such as Parent #13's who believed that children enjoy using touch screen devices and this in turn impacts their learning. A component of this enjoyment is reflected in the interface design of touch screen devices, in that the effort expectancy of touch screen devices is appropriate for preschool aged children. This was indicated by the comments of Parent #16 who stated that the interface features of touch screen devices are intuitive, hence making them age appropriate and a childhood friendly tool for learning.

Within the discussion of the appropriateness of touch screen devices parents also discussed App design. For example, Parent #16 believed that the Apps available for touch screen devices were appropriate and engaging for children. Measuring children's engagement within their use of Apps via touch screen devices was another objective of this study (see Chapter 6). Whilst acknowledging the appropriateness of touch screen devices for children, Parent #36 also pointed out that regardless of it being an appropriate tool there needs to be adult intervention or participation in the form of monitoring children's technology with touch screen technology and an appropriate selection of children's Apps. Chapter 5 analyses the developmental appropriateness of Apps designed for preschool education purposes.

Most parents' (87.5%) reported that they were confident about knowing what an App is (see Table 4.13). This suggests that parents are aware of an App's purpose and the context in which it is used.

Table 4.13

Parents' self-rated level of confidence of knowing Apps

Level of confidence	n	percentage
I am very confident that I know what an app is	70	87.5
I have heard what an app is, but I am not totally sure	10	12.5
I have no idea what an app is.	0	0

Most parents agreed that Apps designed for preschool educational purposes were assistive of children's learning, *Mean* = 3.79, *SD* = 0.87 (see Figure 4.4). This consolidates data from previous sections in this chapter where parents discussed the appropriateness of digital technology for young children's learning, in that parents do consider these tools appropriate for young children's learning and development. This study further tested whether or not children did actually learn via the use of Apps designed for preschool children's numeracy learning (see Section 6.10).

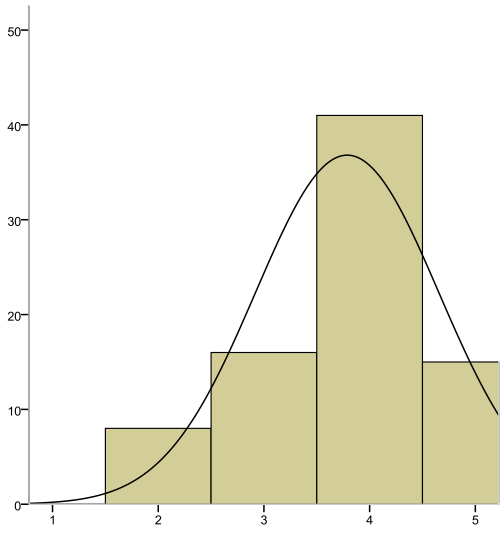

Figure 4.4. Parents' attitudes towards Apps designed for preschool educational purposes are indeed assistive of children's learning devices (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree).

At the end of the questionnaire, parents were asked to provide any other comments (see Appendix J). Seventeen of the 80 parents provided comments. Themes were identified from

the seven categories based upon the UTAUT2. The number in brackets represents the frequencies of the factors (some comments were categorised into multiple categories).

Category 1: performance expectancy (8)
Category 2: effort expectancy (0)
Category 3: social influence (6)
Category 4: facilitating conditions (4)
Category 5: hedonic motivation (1)
Category 6: price value (1)
Category 7: habit (0)

Three examples from parents include:

Question: Are there any other comments you would like to make?
Parent #4: Children should use the tools when they are young, hence aiding learning. It is part of children's life and future.
Parent #38: Yes, educational media can assist a child's learning. But, at such a young age their learning should be more active and interactive through technology, nature and reading books.
Parent #45: Technology really does rule the world these days, but I'm hoping to encourage my child to go outside and technology as opposed to sit in front of a computer or tv.

These findings indicate that the performance expectancy of digital technology and associated devices are indeed assistive of children's learning, as illustrated in comments by Parent #4. Furthermore, Parent #4 explains that digital technology allows children to practise the skills associated with their future education and working lives.

However, other comments suggested that there is still a dichotomy of opinion towards the use of digital technology in early childhood settings. Examples of such attitudes were demonstrated by Parent #38 and Parent #45, who believed that more traditional approaches to children's learning should be employed before digital technology, despite acknowledging that digital devices were prevalent in children's lives and that digital technology can assist children's learning. Hence it would appear that acceptance of digital technology within early

childhood communities would sit beside traditional forms of technology rather than act as an alternative.

4.5 Educators from Participating Child Care Centres

This section reports the educators' roles, gender, age, highest qualification and their technology skills levels.

Of the 49 educators, there were three directors (6.1%), two assistant directors (4.1%), two qualified teachers (4.1%), 29 qualified caregivers (59.2%), four unqualified caregivers (8.2%) and nine casual staff (18.4%). This indicates that the majority of educators were qualified caregivers; to hold this title one must have completed or be working towards (at minimum) the completion of a Certificate III in Early Childhood Education and Care.

Of the 49 educators, four (8.2%) were male, and 45 (91.8%) were female. Their ages ranged from 18 to 59 years, with 17 (34.7%) from 18-29 years, 15 (30.6%) from 30-39 years, 10 (20.4%) from 40-49 years, and 7 (14.3%) from 50-59 years. As would be expected, the age range is much wider with educators than parents, thus covering a wider range of generational attitudes towards technology.

The educators were also asked about their length of time as educators within the particular service they were working in. This ranged from 2 months to 30 years. Table 4.14 presents the mean and standard deviation of months of being educators.

Table 4.14

Mean and Standard Deviation of Months of Being Educators

	Mean	*SD*	*N*
Months of being educators	61.02	74.22	49

Figure 4.5 shows that majority of the educators had been working from 2 months to 60 months (5 years). This result was not unexpected as the turnover rate within child care centres is high (Bainbridge, 2013). This therefore influences the continuity of care and practice these services can provide.

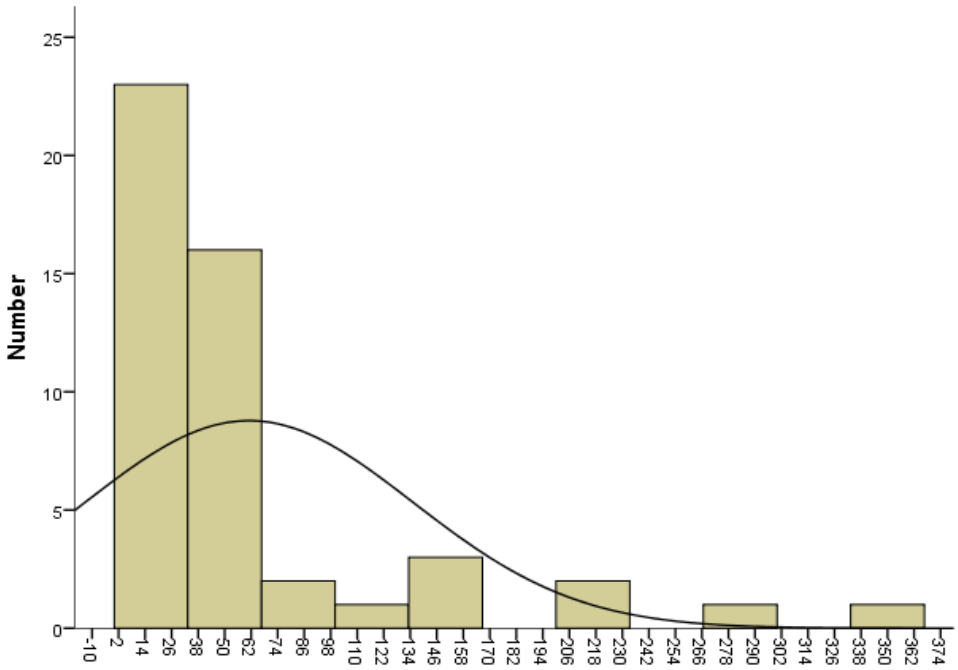

Figure 4.5. Months of being educators.

The educators' highest qualifications ranged from high school to postgraduate. The most common qualification was a diploma followed by Certificate level training (see Table 4.15). These results are consistent with the minimum standards of education required of those working in the child care industry (ACECQA, 2016).

Table 4.15

Educators' Highest Qualification

Highest qualifications	n	Percentage
High school	3	6.1
Certificate	14	28.6
Diploma	26	53.1
Bachelor	3	6.1
Postgraduate	3	6.1

Note. N = 49.

All educators used technology at home. According to their self-report from a 5-point scale (1 = novice user, and 5 = expert user), educators' skills of using digital technology ranged from 1 to 5, *Mean* = 3.00, *SD* = 0.82 (see Figure 4.6). These results indicate that educators are not confident users of digital technology. Whilst not needing to be experts in the use of technology to provide children with necessary skills to utilise digital technology themselves, it identifies a need for digital technology training for educators to develop the confidence and maximise skills to facilitate best practice.

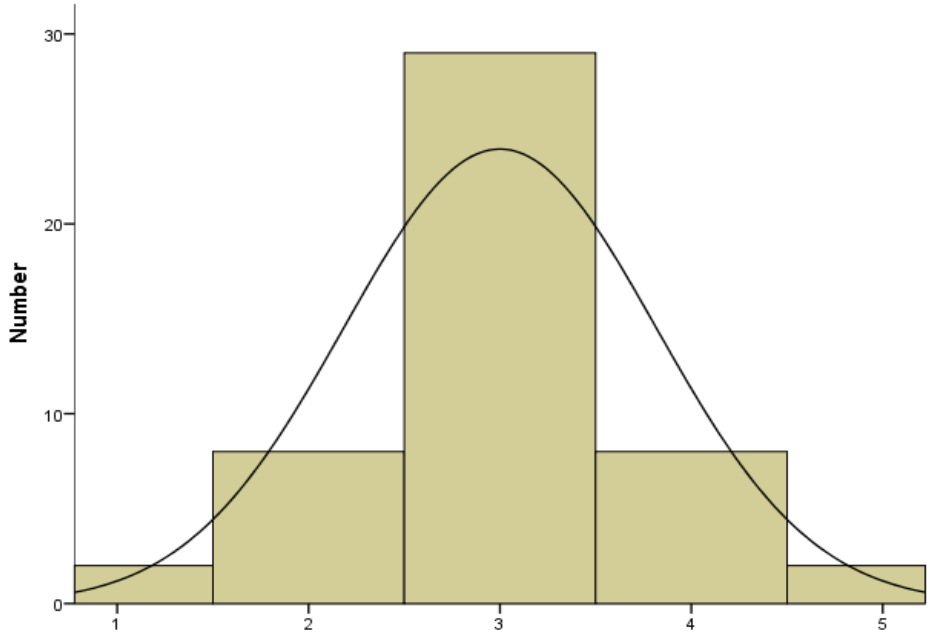

Figure 4.6. Educators' self-report of skills of using technology.

4.6 Digital Technologies Accessed within the Child Care Centre

The 49 educators were asked to identify which digital technologies their children had access to within care. The main digital technologies were computers and the Internet. No children

had access to Smartphone, video games, video iPod, hand-held video game player, iPad, cable television or e-Readers.

Table 4.16

Access the Digital Technologies within Child Care Centres/Classrooms

	n	Percentage
Computer (laptop or desktop)	31	63.3
Internet	27	55.1
Smartboard	17	34.7
Television	14	28.6
DVD player/Blue ray player	12	24.5
Smartphone	0	0
Video games (e.g., Xbox, Playstation, or Wii)	0	0
Video iPod or similar device	0	0
Handheld video game player (e.g., GameBoy, PSP or Nintendo DS)	0	0
IPad or similar tablet device	0	0
Cable television (Foxtel/Austar)	0	0
Kindle, Nook or similar e-Reader	0	0

Note. N = 49.

The five devices (computers, Internet, Smartboard, television and DVD player/blue ray player) which were used by children in the child care centres were further analysed. Computers were used between monthly and at least once a semester, while the Internet and Smartboard were used between at least once a semester and yearly. It was also found that "TV" and "DVD player/blue ray player" were used yearly at the maximum (see Table 4.17). These results indicate that within the early childhood services there were limited digital technologies compared to the home environment. Furthermore their use was much lower, other than Smartboard, which is to be expected due to its price and relationship to educational environments. In addition, the primarily accessed and used devices were ones such as standard laptop/desktop computers, which are associated with fine motor control issues for young children, and one-way interactional devices such as television and DVD or Blue ray players.

Table 4.17

Access the Media Devices within Child Care Centres/Classrooms (Means)

	Mean	*SD*	*n*
Computer (laptop or desktop)	3.59	2.34	49
Internet	4.24	2.17	49
Smartboard	4.27	2.41	49
Television	5.41	1.15	49
DVD player/Blue ray player	5.53	1.04	49

Note. 1 = daily, 2 = weekly, 3 = monthly, 4 = at least once a semester, 5 = yearly, and 6 = has never been used.

4.7 Educators' Attitudes Towards the Use of Digital Technology in Early Childhood Education

This section reports on four primary results: (a) educators' attitudes towards digital technology in early childhood, (b) educators' attitudes towards digital technology for curricula teaching (c) educators' attitudes towards digital technology for children's development, and (d) educators' attitudes towards the use of touch screen devices for preschoolers.

4.7.1 Educators' Attitudes towards Digital Technology in Early Childhood

This first section reports on educators' opinions about the use of digital technology in early childhood education in the following order: (a) educators' views towards digital technology as an urgent priority, (b) educators' views towards digital technology integration into child care centre, (c) educators' views towards digital technologies enhancement of educators' abilities to teach, (d) educators' views towards funding to incorporate digital technology into child care centres, and (e) educators' views towards the future use of digital technology.

Table 4.18 shows that the educators chose higher than agree that: (a) digital technology was an urgent priority; (b) digital technology should be integrated into child care centres; (c) educators' abilities to teach should be enhanced through digital technology; and (d) digital technology should be used in future teaching. It was also noted that educators believed that there was not enough funding to incorporate digital technology into child care centres.

Table 4.18

Educators' View towards Digital Technology

	Mean	*SD*	*N*
Digital technology is an urgent priority	3.31	1.26	49
Digital technologies integration in child care centre	3.53	1.12	49
Digital technologies enhancement of educators' abilities to teach	3.78	0.69	49
Funding to incorporate digital technology into child care centres	2.61	1.12	49
Future use of digital technology	3.65	0.81	49

Note. The means are presented using a 5 point scale anchored (1= strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree).

Table 4.19 presents the percentages of educators' opinions about the use of digital technology in early childhood education. It was found that almost half of the educators (49.0%) chose higher than agree in their view towards digital technology as an urgent priority. More than half of the educators believed that: (a) digital technology should be integrated in child care centres (57.1%), (b) digital technology enhances educators' abilities to teach (71.4%), and (c) that there should be a future use of digital technology (58.2%). Just below half of the educators (44.8%) strongly disagreed or disagreed that funding was needed to incorporate digital technology into child care centres. These results clearly illustrate that educators understand the role of digital technology in early childhood and have an understanding of the technological age in which children are growing up. There is a willingness to accept the use of digital technology as a way to enhance pedagogical practice. However, there is also a clear realisation that within current funding models for children's services that the integration of digital technology may not be feasible when compared to other needs for funding.

Table 4.19

Educators' Opinions about the Use of Digital Technology in Early Childhood Education (Percentages)

	1	2	3	4	5
Digital technology is an urgent priority	12.2	12.2	26.5	30.6	18.4
Digital technologies integration in child care centre	4.1	16.3	22.4	36.7	20.4
Digital technologies enhancement of educators' abilities to teach	0	4.1	24.5	61.2	10.2
Funding to incorporate digital technology into child care centres	20.4	22.4	36.7	16.3	4.1
Future use of digital technology	0	6.1	36.7	42.9	14.3

Note. (a) All above figures represent percentages within each item. (b) 1= strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree.

The educators were also asked to provide the reasons for integrating digital technology into child care centres. Table 4.20 presents the percentages of the four reasons. The majority of educators agreed that familiarising children with the world of new technologies and the curricular and educational benefits were the main reasons for integrating digital technology into child care centres. This highlights that educators understand the role of technology for children in terms of their educational and working futures. Furthermore, there is a belief that digital technology is assistive of children's learning. Of interest was that educators did not feel parental expectations were a reason to implement digital technology into service delivery. This could be due to not receiving requests from parents to integrate digital technology into the curriculum or that as pedagogical leaders it is their responsibility to decide upon the appropriateness of digital technology within their teaching.

Table 4.20

Reasons for Integrating Digital Technology into Child Care Centres

	Yes		No	
	n	percentage	*n*	percentage
Familiarising children with the world of new technologies	43	87.8	6	12.2
The curricular and educational benefits	39	79.6	10	20.4
The recreational value to the child	10	20.4	39	79.6
Parental expectations	6	12.2	43	87.8

Note. N = 49.

Six of the 49 educators also identified other reasons. Themes were identified from the seven categories based upon UTAUT2. The number in the brackets represents the frequencies of the factors (some comments were categorised into multiple categories).

Category 1: performance expectancy (5)
Category 2: effort expectancy (0)
Category 3: social influence (2)
Category 4: facilitating conditions (0)
Category 5: hedonic motivation (0)
Category 6: price value (0)
Category 7: habit (0)

Three examples from educators include:

Question 13: In your option, what are the other reasons for integrating digital technology into child care centres?
Educator #1: Multi-literacies and cross media communications are embedded in our current culture. Familiarisation with media is part of being a successful + competent communicator [sic].
Educator #27: Researching topics of interest of the child e.g. Dinosaurs, space, art.
Educator #30: Complements storytelling [sic].

The results highlight that it is expected that digital technology addresses specific pedagogical needs, in this case the three educator examples highlight that digital technology can allow for literacy and storytelling to be enhanced [sic]. Therefore educators view digital technology as a specific tool to enhance their practice.

Many educators agreed that training in the use of digital technology should be mandatory (61.2%) (see Table 4.21). This result suggests that educators identify a need for training in using digital technology as a pedagogical tool.

Table 4.21

Educators' View towards Training for Educators in the Use of Digital Technology

	n	percentage
Mandatory and done annually	10	20.4
Mandatory and done when new digital technology is introduced	20	40.8
Optional for staff	16	32.7
Not necessary	3	6.1

Note. N = 49.

4.7.2 Educators' Attitudes towards Digital Technology for Curricula Teaching

This section reports on educators' attitudes towards the use of digital technology for teaching literacy, numeracy, science, art and physical education from a 5-point scale (1 = strongly disagree, and 5 = strongly agree).

Table 4.22 shows that most educators thought that use of digital technology could be used to teach literacy, numeracy, science, art and to a lesser extent physical education.

Table 4.22

Educators' Opinions about the Use of Digital Technology Teaching Literacy, Numeracy, Science, Art and Physical Education (Means)

	Mean	*SD*	*N*
Numeracy/mathematics	4.33	0.69	49
Science	4.16	0.77	49
Literacy/language	4.14	0.84	49
Art	3.98	0.95	49
Physical education	2.94	1.31	49

Note. (a) The means are presented in order, from highest to lowest, using a 5 point scale anchored (1= strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree). (b) A repeated measures ANOVA on the above means revealed a significant effect, F (4, 192) = 29.63, $p < .01$.

Table 4.23 presents the percentages of educators' attitudes towards the use of digital technology for teaching literacy, numeracy, science, art and physical education. These results clearly indicate that educators see the value of digital technology in teaching all curricula areas and to a lesser extent physical education, signifying that digital technologies can enhance learning within in a number of curricula areas.

Table 4.23

Educators' Opinions about the Use of Digital Technology Teaching Literacy, Numeracy, Science, Art and Physical Education (Percentages)

	1	2	3	4	5
• Numeracy/mathematics	0	4.1	0	55.1	40.8
• Science	0	6.1	4.1	57.1	32.7
• Literacy/language	0	6.1	10.2	46.9	36.7
• Art	0	12.2	8.2	49.0	30.6
• Physical education	14.3	28.6	22.4	18.4	16.3

Note. (a) All above figures represent percentages within each item. (b) 1= strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree.

4.7.3 Educators' Attitudes towards Digital Technology for Children's Development

This section reports educators' attitudes towards the use of digital technology for children's development in the domains of cognitive development, gross motor skills development, fine motor skills development, language development and social development.

Table 4.24 shows that most educators thought that use of digital technology could be used for children's development in all domains.

Table 4.24

Educators' Opinions about the Use of Digital Technology for Children's Development in the Domains of Cognitive Development, Language Development, Fine Motor Skill Development, Social Development and Gross Motor Skill Development (Means)

	Mean	*SD*	*N*
Cognitive development	4.35	0.86	49
Language development	3.98	1.07	49
Fine motor skill development	3.88	1.05	49
Social development	3.41	1.19	49
Gross motor skill development	3.04	1.31	49

Note. (a) 5 point scale anchored (1= strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree). (b) A repeated measures ANOVA on the above means revealed a significant effect, F (4, 192) = 19.04, $p < .01$.

Table 4.25 presents the percentages of educators' attitudes towards the use of digital technology for children's development. These results confirmed that educators viewed digital technology as being an effective tool for developing children's thinking and skills. Of interest is that whilst educators believed digital technology could have a positive impact on language skills, they were less positive regarding the social implications of digital technology. Often language is strongly associated with social technology, however these results highlighted that educators could see the distinction between the development of language via digital devices and children's social interactions.

Table 4.25

Educators' Opinions about the Use of Digital Technology for Children's Development in the Domains of Cognitive Development, Language Development, Fine Motor Skill Development, Social Development and Gross Motor Skill Development (Percentages)

	1	2	3	4	5
• Cognitive development	0	8.2	0	40.8	51.0
• Language development	6.1	6.1	2.0	55.1	30.6
• Fine motor skill development	4.1	10.2	6.1	53.1	26.5
• Social development	8.2	16.3	18.4	40.8	16.3
• Gross motor skill development	8.2	38.8	12.2	22.4	18.4

Note. (a) All above figures represent percentages within each item. (b) 1= strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree.

4.7.4 Educators' Attitudes towards the Use of Touch Screen Devices for Preschoolers

This section firstly reports on educators' opinions towards the use of touch screen devices. It then presents their knowledge about Apps and the usefulness of Apps designed for preschool educational purposes.

Most educators thought the use of touch screen devices were appropriate for preschool age children, *Mean* = 3.82, *SD* = 0.93 (see Figure 4.7).

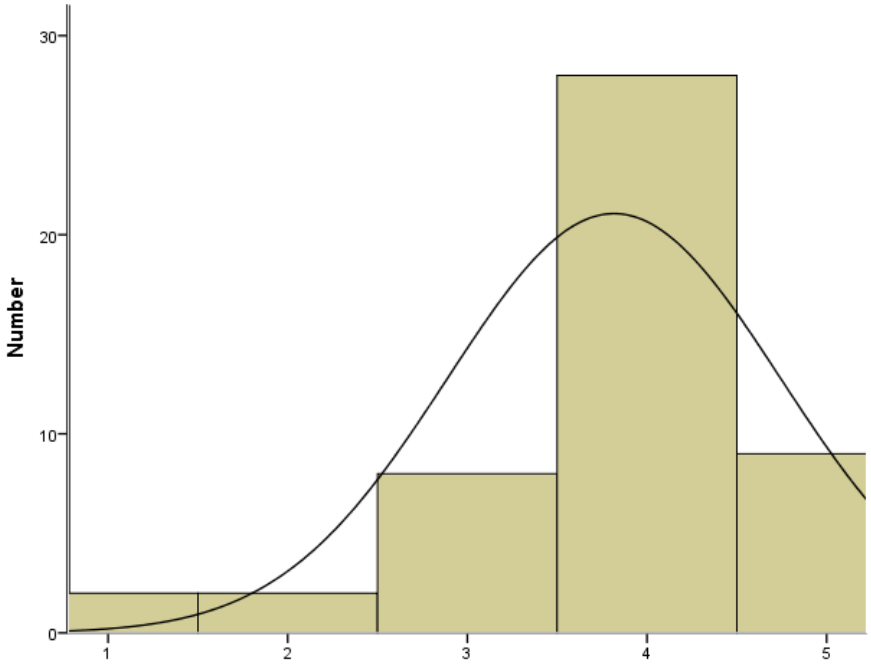

Figure 4.7. Eduactors' attitudes towards the appropriateness of use of touch screen devices (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree).

Thirty-eight of the 49 educators also offered reasons for why they thought touch screen devices were appropriate for preschool aged children. Themes were identified from the seven categories based upon UTAUT2. The number in the brackets represents the frequencies of the factors (some comments were categorised into multiple categories).

Category 1: performance expectancy (22)

Category 2: effort expectancy (17)

Category 3: social influence (11)

Category 4: facilitating conditions (9)

Category 5: hedonic motivation (5)

Category 6: price value (0)

Category 7: habit (0)

Three examples from educators include:

Question 13: Do you agree that touch screen devices, such as Apple's iPad, Sony's Tablet S or Samsung's Galaxy Tab are appropriate for use by children aged 3 to 4 years of age? Please explain your reasons why

Educator #5: To enhance children's ICT skills and particularly extend children's thinking relating to topics of interest and curricula areas. Increase problem solving skills in children. Provide educators with in's [sic].

Educator #30: The early years and this includes junior primary, needs to focus on the values of "old fashioned technology", creativity, imagination, social, lang. skills and self-regulation [sic].

Educator #31: I have seen an iPad in use by preschool and feel some programs have content that is highly educational and engaging to pre-schoolers' [sic].

These results indicate that educators believe that touch screen devices are appropriate for children. The primary motivation identified by educators revolved around the performance expectancy of the devices. For example, Educator #5 listed a range of potential benefits from specific technical skills of using the technology to assist cognitive processing within problem solving skills. Educator #31's response shows that observing other's use of iPads within their practice has allowed her to see the potential benefits and therefore be more willing to engage and integrate digital technology within her own practice, therefore she has been socially influenced into accepting digital technology and its potential benefits.

Not all early childhood educators however, are accepting of digital technology, such as touch screen technology. Educator #30 argues that children should engage in traditional forms of play rather than digital versions. By the virtue of her comments she was suggesting that digital technology might not facilitate creativity, imagination, social and language skills, as well as self-regulation.

Educators' confidence of knowing Apps was also rated on a 3 point scale: 1= I don't know what an App is, 2 = I have heard what an App is, but I'm not totally sure, and 3 = I am very confident that I know what an App is. Only one educator (2%) reported that she did not know what an App was, eight (16.3%) knew Apps to a degree and 40 (81.6%) were very confident

about Apps. This shows that the majority of educators are aware of Apps and their purpose. An interesting point to note is that Educator #30 was the only educator who stated she did not know what an App was, and her response to the appropriateness of digital technology was that children needed to focus on the values of "good old fashioned" play.

Most educators agreed that Apps designed for preschool educational purposes were assistive of children's learning, *Mean* = 3.88, *SD* = 0.82 (see Figure 4.8).

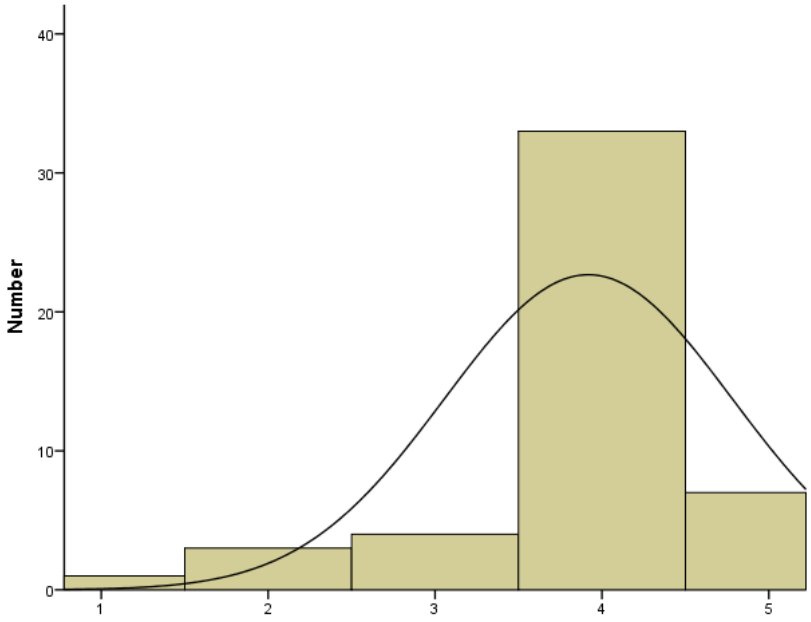

Figure 4.8. Educators' agreement level towards whether apps designed for preschool educational purposes is indeed assistive of children's learning (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree).

Thirty of the 49 educators offered further opinions about significant obstacles that prevented them from incorporating more digital technology into their child care facility. Themes were identified from the seven categories based upon UTAUT2. The numbers in the brackets represent the frequencies of the factors (some comments were categorised into multiple categories).

Category 1: performance expectancy (3)

Category 2: effort expectancy (5)

Category 3: social influence (8)

Category 4: facilitating conditions (26)

Category 5: hedonic motivation (0)

Category 6: price value (2)

Category 7: habit (0)

Three examples from educators include:

Question 18: What are the most significant obstacles which may prevent you from incorporating more digital technology into your child care facility?

Educator #1: Staff confidence in how to use it; finances; time to learn and develop staff skills [sic].

Educator #2: Funding. The limits of my understanding of the full potential of these devices needs more PD [sic].

Educator #16: Costs of device and internet costs for downloads, acceptance by staff, respect of devices by children, not trashed/broken easily [sic].

These results identify the primary issues surrounding the inclusion of digital technology into child care settings were facilitating conditions. For example, Educator #2 identified funding as the primary factor influencing integration of digital technology, which clearly has links to the initial cost, upkeep and durability of digital technology, as identified by Educator #16. In addition to the financial implications of digital technology, staff confidence, acceptance and potentially limited skills in the use of digital technology are all potential issues identified by Educators #1 and #2 that prevented them from incorporating more digital technology into their services.

Eleven of the 49 educators provided further comments in relation to the use of digital technology in child care centres. Themes were identified from the seven categories based upon UTAUT2. The number in the brackets represents the frequencies of the factors (some comments were categorised into multiple categories).

Category 1: performance expectancy (4)

Category 2: effort expectancy (0),

Category 3: social influence (5),

Category 4: facilitating conditions (5).

Category 5: hedonic motivation (1)

Category 6: price value (0), and

Category 7: habit (0).

Three examples from educators include:

Question 19: Are there any other comments you would like to make?

Educator #1: Would probably say that it's only been in very recent times that I've felt that as an educational institution that we have a responsibility to introduce educational media into the curricula responsibility as its here to stay and many chn are already familiar with them [sic].

Educator #2: One of the most beneficial aspects of technology use that I have noticed is the empowering aspect of it. With cameras it gives children a voice, computer games a sense of independence and achievement [sic].

Educator #30: I think TV media, i.e.: ABC for Kids and DVD's of books are enough Ed media in E.C. settings. As I mentioned earlier "old fashion' technology and using TV or DVD's to compliment lang and literacy are sufficient [sic].

These results highlight the current conflict in the early childhood community. On the one hand, Educator #1 discusses the need to integrate new forms of digital technology into service delivery and Educator #2 discusses digital technology in the lives of children as an empowering force, allowing children a sense of autonomy via their mastery of digital technology. Conversely, Educator #30 did not see the need for change and would rather not integrate additional forms of digital technology, rather highlighting one-way, passive media such as television and DVDs as being enough digital technology for children. This demonstrates a clear dichotomy of opinion regarding the integration of digital technology into early childhood.

4.8 Comparing Parental and Home Digital Technology to Educator and Child Care Centre Results

This section reports on two comparative results: (a) children's access to digital technology at home and child care centres, and (b) children's parents and educators attitudes towards digital technology.

4.8.1 Children's Access to Digital Technology at Home and Child Care Centres

In this section, children's access to digital technology at home and child care centres is compared. Children did not have access to Smartphone, video games, video iPod, handheld video game player, iPad, cable TV, and e-Reader within the child care centres. Thus computer, Internet, Smartboard, television, DVD player, which children had access to both at home and child care centres, were compared only. There was a significant difference in the frequencies of access of TV and DVD between the home and child care centres. Conversely children had more frequent access to "Smartboard" in child care centres than at home (see Table 4.26). However children's use of the computer and Internet was similar both on care and home. These results highlight a difference between technologies accessed within the home compared to that of child care centres. Children are accessing and using more digital technology at home, which will have implications for their learning styles and educational preferences.

Table 4.26

Children's Access to the Five Devices at Home and in Child Care Centres (Means)

	Child care centres $n = 49$	Home $n = 80$	*t (127)*	*p*
Computer	3.59	3.76	0.50	ns
Internet	4.24	4.24	0.02	ns
Smartboard	4.27	5.95	6.11	< .01
TV	5.41	1.36	23.71	< .01
DVD player	5.53	2.39	16.21	< .01

Note. 1 = daily, 2 = weekly, 3 = monthly, 4 = at least once a semester, 5 = yearly, and 6 = has never been used.

4.8.2 Children's Parents' and Educators' Attitudes towards Digital Technology

This section compares parents' and child care centre educators' attitudes towards: (a) self-reported skills of using technology, (b) digital technology as an urgent priority and its integration into child care services, (c) digital technology for children's curricula development, and (d) digital technologies impact for children's development.

4.8.2.1 Skills of using technology

According to their self-reports, educators' skills of using technology were significantly lower than the parents' (see Table 4.27). This could indicate that parents use digital technology more often within their home and working practice than educators and consequently could be more familiar with the technology and how to use it. It does not, however, mean that parents would know how to use the technology more effectively as a pedagogical tool for young children than educators.

Table 4.27

Educator and Parents Skills of Using Technology (Mean)

	Educators *n* = 49	Parents *n* = 80	*t (127)*	*p*
Skills of using technology	3.00	3.49	3.90	< 0.01

Note. 1 = novice user and 5 = expert user.

4.8.2.2 Attitudes towards the statements "digital technology is an urgent priority" and "digital technologies integration in child care centres"

It was found that there was no difference between educators' and parents' views towards the statements "digital technology is an urgent priority" and "digital technologies integration in child care centres" (see Table 4.28). This result indicates that despite the different roles that parents and educators have in relation to technology in children's lives, they share the same opinion regarding the integration and priority of digital technology into child care services.

Table 4.28

Educator and Parent Attitudes towards the Integration and Urgency of Digital Technology into Child Care (Mean)

	Educators *n* = 49	Parents *n* = 80	*t (127)*	*p*
Views towards "digital technology is an urgent priority"	3.31	3.31	0.31	ns
Views towards "digital technology' integration in child care centres"	3.53	3.53	0.28	ns

Note. 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree.

4.8.2.3 Attitudes towards the use of digital technology for curricula teaching

Educators' attitudes towards the use of digital technology for teaching science, art and physical education were significantly higher than parents'. There was no significant differences between educators' and parents' attitudes towards use of digital technology for

teaching numeracy and literacy (see Table 4.29), however educators consistently rated the educational potential of digital technology higher than parents, which could be owing to their background and training within early childhood.

Table 4.29

Educator and Parent Attitudes towards the Use of Digital Technology for Curricula Teaching (Mean)

	Educators *n* = 49	Parents *n* = 80	*t (127)*	*p*
Numeracy/Mathematics	4.33	4.19	1.07	0.29
Literacy/language	4.14	4.13	0.14	0.89
Science	4.16	3.60	3.82	<0.01
Art	3.98	3.45	2.92	< 0.01
Physical education	2.94	2.30	3.12	<0.01

Note. 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree.

4.8.2.4 Attitudes towards the use of digital technology for children's development

Educators' attitudes towards the use of digital technology for children's development of gross motor skills development, language development and social development were significantly higher than parents'. There was no significant difference between educator and parent attitudes towards the use of digital technology for children's cognitive and fine motor skills development (see Table 4.30). These results indicate that, as with curricula development, educators for the most part view the potential of digital technology more positively than parents. Of particular interest is that educators rated the potential of digital technology to improve social development (*Mean* = 3.41) much more than parents (*Mean* = 2.45). This finding highlights that educators believe that digital technology can impact children's social development far more than parents; however it may also indicate that parents value the social interactions their children receive in child care and do not believe that digital technology will help in this valued domain.

Table 4.30

Educator and Parent Attitudes towards the Use of Digital Technology for Children (Means)

	Educators $n = 49$	Parents $n = 80$	$t\ (127)$	p
Cognitive development	4.35	4.21	0.85	0.40
Language development	3.98	3.46	2.95	< 0.01
Fine motor skills development	3.88	3.93	0.27	0.79
Social development	3.41	2.45	5.07	< 0.01
Gross motor skills development	3.04	2.01	5.13	< 0.01

Note. 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree.

4.9 Summary

Educators rated their self-confidence in the use of technology lower than parents, which has implications for effective digital technology integration within early childhood settings. It was found that home settings provided greater access and more frequent use of technology than child care centres. There were significant differences between family income and access to digital devices within the home, potentially causing a digital divide when coupled with the limited access to digital devices within care settings, which will be discussed in further detail in Chapter 7.

Both educators and parents believed that digital technology should be integrated into child care centres. The primary reasons identified by educators and parents regarding the integration of digital technology revolved around performance expectancy. Although there was a consensus from both educators and parents that Apps designed for preschool education were age appropriate and indeed assistive of children's learning, educators consistently held firmer beliefs that digital technology could be used to enhance educational curricula and children's developmental outcomes than parents. Of importance was that both educators and parents expressed their concerns over the impact of digital technology on children's social development; a point that will be discussed in further detail in Chapter 7. Educators identified

potential issues preventing the integration of digital technology into child care centres, which revolved around facilitating conditions, such as funding, cost of the devices, as well staff confidence and lack of training. Implications for this will be discussed in further detail in Chapter 7. The next chapter will present the results of the App review study, with a specific focus on the design role of preschool numeracy Apps and whether they are developmentally appropriate.

Chapter V: Testing the Purpose and Developmental Appropriateness of Apps Designed for Preschool Numeracy Education

5.1 Introduction

Chapter 4 identified that educators and parents believed that gestural interface devices and associated Apps assisted children's learning and were appropriate for young children. One of the objectives of this chapter is to determine if Apps designed for young children are indeed developmentally appropriate or not. The chapter answers the research question: "*What are the primary roles of the most popular Apps designed for preschool aged children's numeracy learning?, and are the Apps design developmentally appropriate for children*?". The chapter presents the results from the App's detailed ratings in the Gestural Interface App Rating Scale (GIARS), followed by the relationships among the nine areas in GIARS and their price range. It then reports the App's ratings in the Math App Appraisal Scale (MAAS), followed by the relationship between the App's costs and their rankings in GIARS and MAAS.

5.2 Developmental Appropriateness of the Sample Apps

Fifty Apps were chosen from the Game Centre in Apple website in the numeracy area of early childhood education. Based upon the Haughland Scale (Haughland & Wright, 1997), a Gestural Interface App Rating Scale (GIARS) was designed to rate Apps as developmentally appropriate. When the rating was above 6 it was considered to have met enough criteria to be considered developmentally appropriate (Haughland & Wright, 1997). It was found that 26 (52%) of the 50 Apps were rated below 6 and 24 (48%) were rated between 6 and 9. Table 5.1 presents the Mean and SD for the 50 Apps. These findings show that less than half of the Apps were identified as being developmentally appropriate for children.

Table 5.1

Developmental Appropriateness of the Chosen Apps

	Mean	*SD*	*N*
Developmental appropriateness	5.34	1.45	50

Figure 5.1 also shows that one App was rated within the range of 1 to 2; three Apps were rated within the range of 2 to 3; eight Apps were rated within the range of 3 to 4; eight Apps were rated within the range of 4 to 5; six Apps were rated 5 to 6, 19 Apps were rated within the range of 6 to 7; and five Apps were rated within the range of 7 to 8. As developmental appropriateness was classified as scores over 6, this finding indicates that 38% of Apps only just met developmental appropriateness scoring between 6 and 7. Therefore, it can be said that Apps designed to teach numeracy to preschool aged children cannot be considered as highly developmentally appropriate as rated by GIARS, as only 10% of Apps scored between 7 to 7.5 and no Apps scored between 7.5 to 9.

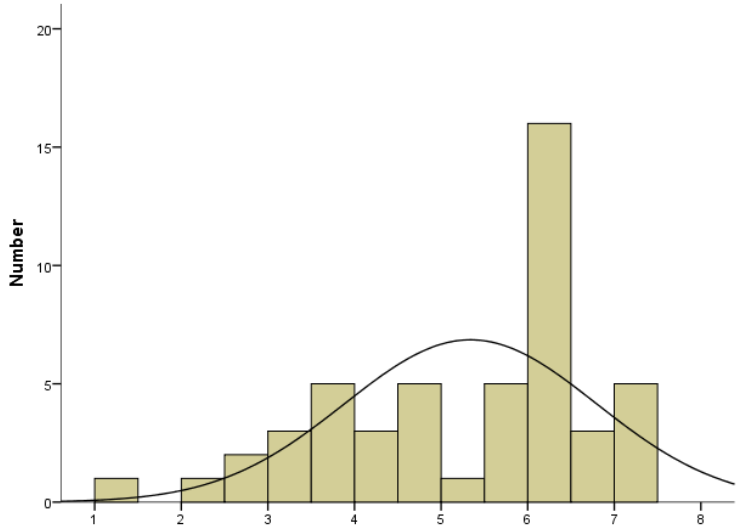

Figure 5.1. Developmental appropriateness of the sample Apps.

Of the 50 Apps, 31 (62%) were free and 19 (38%) cost between $0.99 to $5.49. Table 5.2 shows the number and percentage of the price characteristic of the chosen Apps. This indicates that 80% of the most popular numeracy Apps from Apple's App Store was either free or cost less than $1.00.

Table 5.2

Price Characteristic of the Chosen Apps

Price characteristic	*n*	Percentage
Free	31	62
$0.99	9	18
$1.99	5	10
$2.99	3	6
$5.49	2	4

The variables "developmental appropriateness" and "price" were relatively positively correlated, $r = 0.34$, $p = 0.02$. The higher the price of the Apps, the more developmentally appropriate the App. This shows that price does play a factor in the quality of Apps. With 80% of the Apps costing less than $1.00 or being free, this brings into question Apps available for young children may not be developmentally appropriate.

5.3 Detailed Ratings in the GIARS

All 50 Apps were measured based upon the Gestural Interface App Rating Scale (GIARS): age appropriateness, contextual environment, seamlessness, scaffolding, no touch left behind, non-violence, process orientation, real world model and the anatomy of a gesture.

5.3.1 Age Appropriateness

Table 5.3 presents the means and standard deviations for the ratings of the Apps in nine areas in GIARS. The mean of ratings were presented using a scale: 1 = Met, 0.5 = Partially Met, and 0 = Not Met.

It is found that the means of the Apps rated well above 0.5 (partially met) in both categories of the "realistic concepts" and "appropriate methods" in Age Appropriateness. The mean of the rating in "realistic concepts" was significantly higher than "appropriate methods", $t = 3.09$, $p < .01$.

Table 5.3

Detailed ratings in the GIARS (Means)

GIARS AREAS		Mean	*SD*	*F*	*p*
Age Appropriateness	• Realistic concepts	0.85	0.25	*F* (1,49) = 9.57	<.01
	• Appropriate Methods	0.71	0.35		
Contextual Environment	• Minimal Interface Elements for Content	0.74	0.27	*F* (2, 98) = 31.72	<.01
	• Sequence of Learning Present	0.63	0.40		
	• A Clear Beginning	0.41	0.31		
Seamlessness	• Single Finger Flick Movements	0.87	0.24	*F* (3, 147) = 23.68	<.01
	• Responds to Every Contact	0.86	0.25		
	• Transitions Fluid	0.76	0.31		
	• No Time-based Gestures	0.71	0.30		
Scaffolding	• Intentional User Input	0.78	0.31	*F* (3, 147) = 25.73	<.01
	• Functionality	0.58	0.37		
	• Appropriate Action Prompting	0.45	0.42		
	• Reversible Actions	0.42	0.36		
No touch left behind	• Precise selection of content	0.91	0.22	N/A	N/A
The anatomy of a gesture	• Gestures are Minimal and Immediately Clear	0.54	0.39	*F* (1,49) = 0.32	*ns*
	• Clear Feedback	0.48	0.40		
Non-violence	• Free of violent characters and actions	0.94	0.19	*F* (1,49) = 0.27	*ns*
	• Models positive social values	0.92	0.21		
Process Orientation	• Intrinsic Motivation	0.42	0.36	*F* (2, 98) = 10.51	<.01
	• Process Engages, Product Secondary	0.42	0.31		
	• Discover Learning, Not Skill Drilling	0.26	0.29		
Real world model	• Accurate Information	0.86	0.25	*F* (4, 196) = 3.91	.04
	• Concrete Representations	0.82	0.27		
	• Objects Function	0.82	0.27		
	• Simple, Reliable Model	0.81	0.25		
	• Advertising is Minimal or Not Apparent	0.70	0.38		

Note. a) *N* = 50, b) A repeated measures ANOVA was used in all the nine areas of GIARS.

Table 5.4

Detailed ratings in the GIARS (Percentage)

GIARS AREAS		1	*0.5*	*0*
Age Appropriateness	• Realistic concepts	72	26	2
	• Appropriate Methods	54	34	12
Contextual Environment	• Minimal Interface Elements for Content	50	48	2
	• Sequence of Learning Present	48	30	22
	• A Clear Beginning	12	58	30
Seamlessness	• Single Finger Flick Movements	76	22	2
	• Responds to Every Contact	74	24	2
	• Transitions Fluid	58	36	6
	• No Time-based Gestures	48	46	6
Scaffolding	• Intentional User Input	62	32	6
	• Functionality	36	44	20
	• Appropriate Action Prompting	30	30	40
	• Reversible Actions	18	48	34
No touch left behind	• Precise selection of content	71	27	2
The anatomy of a gesture	• Gestures are Minimal and Immediately Clear	34	40	26
	• Clear Feedback	30	36	34
Non-violence	• Free of violent characters and actions	90	8	2
	• Models positive social values	86	12	2
Process Orientation	• Intrinsic Motivation	18	48	34
	• Process Engages, Product Secondary	12	60	28
	• Discover Learning, Not Skill Drilling	4	44	52
Real world model	• Accurate Information	74	24	2
	• Concrete Representations	66	32	2
	• Objects Function	66	32	2
	• Simple, Reliable Model	62	38	0
	• Advertising is Minimal or Not Apparent	56	28	16

Note. (a) Above figures represent percentage within each item. (b) 1 = met, 0.5 = partially met, and 0 = not met.

Table 5.4 shows the percentages of the ratings of the Apps in the age appropriate categories of "realistic concepts" and "appropriate methods". Most of the chosen Apps (98%) were rated either met or partially met in the category of "realistic concepts". However, it was also noted that 12% of the Apps were rated not met in the category "appropriate methods". This shows that the majority of Apps met the criteria for "Age Appropriateness" (see Appendix K).

The concepts taught by the Apps reflected realistic expectations for young children. The focus of the Apps had one or more sound learning objectives, which provided valuable skills and/or knowledge for children within the preschool age which the Apps target. However, whilst learning objectives were mostly appropriate, facilitation of those objectives using teaching methods that reflect young children's emerging cognitive, physical, emotional and social skills was only fully presented in 54% of Apps. Hence, in 46% of Apps the method of teaching did not always meet young children's developmental needs; rather "children" had to adapt to meet the demands of the Apps. This indicates that Apps need to recognise that children approach the App from different developmental levels, since children's abilities in a classroom setting vary greatly.

5.3.2 Contextual Environment

It was found that the mean of Apps were rated above partially met (0.5) in "minimal interface elements for content" and "sequence of learning present". However, the mean of the Apps was rated lower in "a clear beginning" (below 0.5) (see Table 5.3).

Most of the means of the Apps (98%) were rated either met or partially met in the category of "minimal interface elements for content", however the mean of the Apps (88%) was rated as either partially met or not met in the category of "a clear beginning" (see Table 5.4). This shows that within the category of contextual environments there was diversity within Apps' ability to meet criteria (see Appendix K).

The primary issue within contextual environments was "a clear beginning", with 88% of Apps only being partially met or not met. Many Apps did clearly begin with actions that prompted the child to comprehend the environment of the App. For example, a game should make it clear to a child what they are expected to do within the environment to progress in the game; this should also consider the pre-reading child. Many Apps did not provide clear

instructions/prompts about what was needed to start and successfully use the interface designs or relied too heavily on textual instructions. An element that the majority of Apps (98%) either met or partially met was the appropriate use of interface elements. This indicates that designers of Apps for preschool aged children were aware that there should be a minimum number of interface elements so as to not overwhelm children's attention from content. Finally, 78% of Apps had a sequence of learning for children that was either met or partially met. This indicates that the majority of Apps had considered how interactions might be logically extended so that the new actions can be easily learned and translated into expected results.

5.3.3 Seamlessness

It is found that all Apps rated well above partially met in the four categories in this area (see Table 5.3). All the Apps (98%) rated either met or partially met in the category of "responds to every contact" (98%), "transitions fluid" (94%), "single finger flick movements" (98%) and "no time-based gestures" (94%) (see Table 5.4). However, it was also noted that more than half of these Apps (52%) rated lower than partially met (< .5) in the category of "no time-based gestures". This shows that within the category of seamlessness, the majority of Apps met the criteria (see Appendix K).

These results show that the majority of Apps (98%) within this study responded to every contact fully or partially. To clarify, the interface of the Apps should provide feedback when children touch the screen, and the system is responding. Therefore, children will not wonder whether the object is broken or malfunctioning or that they are doing something wrong. Additionally, 92% of the Apps made every transition fluid either partially or fully. Therefore, objects transitioned between sensory input and nothing abruptly appeared or disappeared. Likewise, the Apps allowed for single-finger drag and flick movements on movable content, which 98% of Apps being met or partially met. This allows children with limited fine motor skills to manipulate the Apps appropriately. The lowest rated area within the category of seamlessness was that less than half (48%) of the Apps adhered to not using time-based gestures on content. Over half of the Apps (5) had time-based activations that created mandatory delays for users, which detracts from the sense of a natural environment.

5.3.4 Scaffolding

It was found that the mean of the Apps' ratings was well above partially met (0.5) in the category of "intentional user input". However the mean of the Apps ratings were lower than partially met in both categories of "appropriate action prompting" and "reversible actions" (See Table 5.3).

It was noted in Table 5.4 that most of the chosen Apps were rated met (62%) in the category of "intentional user input". However, most of the chosen Apps were rated below partially met (< 0.5) in the categories of "functionality" (62%), "appropriate action prompting" (70%), and "reversible actions" (82%). This shows that within the category of scaffolding, there were mixed results and that Apps were divided when meeting the criteria in this area (see Appendix K).

The primary category met or partially met in relation to the requirement for intentional user input to activate destructive functions or to cause larger changes or transitions required children's input before there were predetermined changes within the Apps' gameplay. Therefore children needed to develop in terms of their playing capabilities within the game before key changes occurred. In terms of functionality, 80% of Apps met or partially met criteria that, at the appropriate time, the App would show children affordances that can guide them to access unseen content. For example, a list of items may appear that the child needs to achieve, however only those items attained would be highlighted whilst others would appear dull. This implies that more items are listed below; in other words, the shown list is incomplete. The first area that needed attention was that not all Apps ensured that all actions lead to either prompting for the next step in the action sequence or suggest actions once finished. Secondly, the predicting of upcoming results often did not allow for the child to reverse their actions once the action was near completion; thus the child would need to start the entire process again.

5.3.5 No Touch Left Behind

There is only one category in no touch left behind: "precise selection of content", *Mean* = 0.91, *SD* = 0.22. It was found that 98% of the Apps were rated above partially met in this category. This result indicates that Apps allowed children to precisely select objects on the touch screen device. This was done in a variety of ways, from adjusting the physical size of

icons to providing techniques that enabled the selection of smaller content. Hence, more than just responding to every contact, the Apps ensured that children could manipulate and control the interface of the App, taking into account children's developing fine motor skills.

5.3.6 The Anatomy of a Gesture

It was found that the mean of the Apps ratings were slightly above partially met in the category of "gestures are minimal and immediately clear", and below partially met in the category of "clear feedback" (see Table 3). Table 5.4 shows that in both categories of anatomy of a gesture the predominant rating was only partially met when meeting the criteria (see Appendix K).

This result highlights that 74% of Apps either met or partially met the requirement that they provide children with clear gestures that were consistent, therefore actions to begin the game were consistently used throughout the game. This minimises the load required to transition between registration and continuation phases. Twenty six percent of Apps did not make it immediately clear to the children how to specify the command they want to execute. Similarly, 70% of the Apps were either partially met or did not meet the requirement for clear feedback. Therefore, the Apps did not always provide clear feedback for the children at each step to ensure they understood their transition from registration to continuation, and termination gestures. In addition, there were times when Apps did not prompt appropriate action by the children, which could lead to confusion.

5.3.7 Non-Violence

Table 5.3 presents that the mean of the Apps ratings were well above partially met in both categories. Table 5.4 shows that most of Apps were rated Met in both categories. This shows that within the category of non-violence, Apps met the criteria predominantly (see Appendix K).

These results indicated that 98% of Apps contained minimal to no violent objects, characters or actions. Children were not exposed to violence nor did they engage in violent actions within the majority of Apps.

5.3.8 Process Orientation

It is shown that the means of the Apps were rated below partially met in all three categories (see Table 5.3). Table 5.4 shows that most of the chosen Apps were rated either partially met or not met in the category of "intrinsic motivation" (82%), "process engages, product secondary" (88%) and "discover learning, not skill drilling" (96%). This shows that every category within the category of process orientation was over 80% for either partially met or not met within the criteria (see Appendix K).

These results indicate that many Apps were not overly appealing to young children and they did not utilise visual and audio aesthetics to capture children's interests. Furthermore, the majority of Apps were drill-and-practice based and not discovery learning; whereby the product was more important than the process. Many Apps encouraged children to win extrinsic rewards such as smiley faces or virtual prizes, rather than achieving a learning objective.

5.3.9 Real World Model

It is shown that the means for the Apps were rated well above partially met in all the five categories (see Table 5.3). It is shown that most of the Apps were rated either met or partially met in the category of "accurate information" (98%), "advertising is minimal or not apparent" (98%), "concrete representations" (98%), "objects function" (100%) and "simple, reliable model" (84%) (see Table 4). This shows that the majority of Apps rated as met or partially met every category within real world model within criteria (see Appendix K).

These results show that Apps gave factually accurate information to children and that Apps attempted to represent abstract concepts in a concrete fashion, acknowledging that young children learn through concrete learning. Furthermore, the Apps conveyed images of objects and their functions in a simple, reliable model whereby objects functioned appropriately. The only area of concern was that 44% of Apps only partially met or did not meet the expectation that Apps should have no advertising aimed at children.

5.4 Relationships among Areas in the GIARS

This section assessed the relationships among the nine areas in the GIARS: (1) age appropriateness, (2) contextual environment, (3) seamlessness, (4) scaffolding, (5) no touch left behind, (6) the anatomy of a gesture, (7) non-violence, (8) process orientation, and (9) real world model. The Apps were rated across the different areas and examined for differences. Ratings within each one were averaged and analyses performed upon the averages.

Cronbach's alpha was used to measure the internal consistency of rating of the 50 Apps and how closely related the nine areas were as a group. It was found that the nine areas as a group were significantly related, with a high Cronbach value $\alpha = 0.85$.

The inter-item correlation was investigated and Table 5.5 shows the correlations among the ratings of: (a) age appropriateness, (b) contextual environment, (c) seamlessness, (d) scaffolding, (e) no touch left behind, (f) the anatomy of a gesture, (g) non-violence, (h) process orientation, and (i) real world model. It was shown the area "non-violence" was only correlated slighted with the other areas, and if removed, the Cronbach alpha value would increase to 0.87.

Table 5.5

Correlations among the Nine Areas

	2	3	4	5	6	7	8	9
• age appropriateness	0.72**	0.40**	0.62**	0.19	0.40**	0.63**	0.59**	0.36**
• contextual environment		0.35**	0.74**	0.06	0.34*	0.62**	0.65**	0.32*
• seamlessness			0.51**	0.06	0.17	0.44**	0.27	0.73**
• scaffolding				0.03	0.48**	0.49**	0.74**	0.59**
• non-violence					-0.18	0.08	0.16	-0.03
• process orientation						0.27	0.23	0.25
• real world model							0.38**	0.23
• the anatomy of a gesture								0.25
• no touch left behind								

Note. N = 50, * $p < .05$, ** $p < .01$.

Figure 5.2 shows the mean of the ratings among the areas. It was found the mean of the Apps were rated highest in "non-violence" and "no touch left behind", however, the mean of the chosen apps were rated lower in "process orientation", "scaffolding", and "the anatomy of a gesture". Early childhood numeracy Apps scored lowest in "process orientation"; this indicates that the Apps were heavily drill-and-practice styled Apps. This has implications for children's ability to retain and develop knowledge as compared to discovery-styled Apps (Blake et al., 2012).

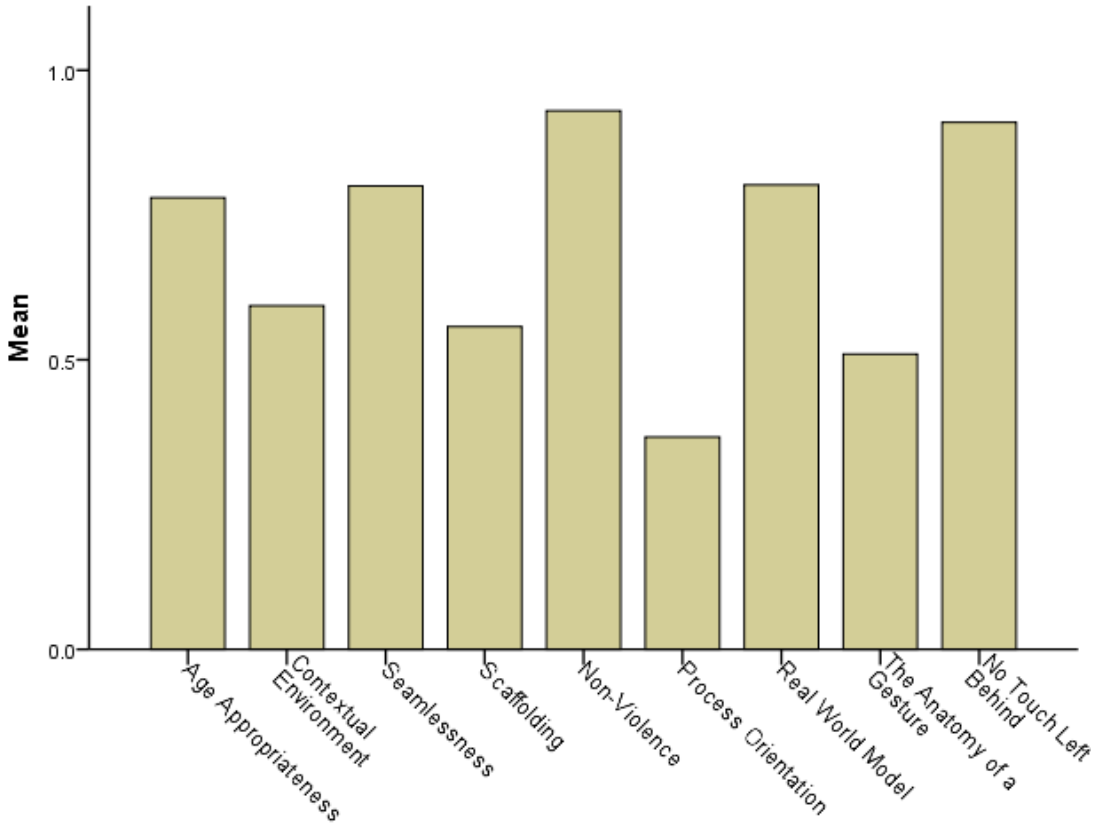

Figure 5.2. Mean of ratings among the areas.

5.5 Apps' Rankings in MAAS

This section reports on the Apps' roles in the Maths Apps Appraisal Scale (MAAS). There were four sections in MAAS. The first section examines the Apps' role according to the type of tasks promoted: explorative, productivity and/or instructive. The second section appraised the degree of cognitive involvement when a learner interacts with the Apps, and the final two sections examine the general pedagogical and operational affordance of the Apps.

5.5.1 Apps' Role

It was found that in early childhood numeracy-related Apps, tasks were instructive, then explorative and lastly, productive. Table 5.6 presents the mean and standard deviation for the ratings of the Apps.

Table 5.6

Apps Rating in Tasks Promoted

	Mean	*SD*	*N*
Explorative	2.71	0.26	50
Productivity	2.72	0.13	50
Instructive	1.96	0.50	50

Note. a) Each item ranged from 1 = always, 2 = to some extent, 3 = never, and 4 = not applicable. b) A repeated measures ANOVA on the above means reveals a significant effect, F (2, 48) = 67.73, $p < .01$.

There are five detailed criteria for each section: explorative (Table 5.7), productivity (Table 5.8) and instructive (Table 5.9) in appraising the Apps' roles. Within MAAS, Apps may have features that overlap between roles; therefore Apps may serve more than one purpose. However the results clearly indicate that most of the Apps were Instructive (see Appendix L). Apps within this study predominantly gave students a variety of different activities, catering for differing ability levels and providing feedback as to the correctness of children's responses.

Table 5.7

Criteria for Explorative Apps (Percentage)

	Explorative Apps (percentage)			
	1	2	3	4
App closely mirrors a model or real-life situation	16.0	52.0	32.0	0.0
Students can enter their own data and observe changes in the model	12.0	22.0	66.0	0.0
Exploration is guided within a predetermined learning discovery framework	2.0	6.0	90.0	2.0
Tasks are goal oriented driving student interest and curiosity	0.0	8.0	90.0	2.0
There are elements of ambiguity and uncertainty fostering personal investigation	0.0	4.0	94.0	2.0

Note. 1 = always, 2 = to some extent, 3 = never, and 4 = not applicable.

Table 5.8

Criteria for Productivity Apps (Percentage)

	Productivity Apps (percentage)			
	1	2	3	4
App lets students to creatively come up with their own design and/or concept	0.0	2.0	98.0	0.0
App allows representing maths content by linking symbolic, numerical and graphical data	0.0	2.0	98.0	0.0
Students are guided in creating their own content/understandings	0.0	4.0	96.0	0.0
Students can represent or present maths content using a variety of different tools (e.g., audio/video recording, measuring devices, etc)	0.0	0.0	100.0	0.0
App tools are intuitive and easy to use	38.0	56.0	6.0	0.0

Note. 1 = always, 2 = to some extent, 3 = never, and 4 = not applicable.

Table 5.9

Criteria for Instructive Apps (Percentage)

	Instructive Apps (percentage)			
	1	2	3	4
App contains a variety of different activities/exercises	42.0	46.0	12.0	0.0
Appropriate feedback is provided to students	26.0	56.0	18.0	0.0
Activities/exercises cater for a range of student ability levels	34.0	52.0	14.0	0.0
Content is meaningful, fostering engagement and rich problem solving	16.0	62.0	22.0	0.0
App contains activities/exercises that are graded and summary data is provided	22.0	26.0	52.0	0.0

Note. 1 = always, 2 = to some extent, 3 = never, and 4 = not applicable.

5.5.2. Apps' Cognitive involvement

A variable "cognitive" was created by adding six items in cognitive involvement and then being divided by 6 to calculate the 50 Apps' degree of cognitive involvement when the researcher interacted with the Apps.

Table 5.10 presents the means and standard deviations for the ratings of the Apps across Cognitive involvement, General pedagogical issues, and Operational issues.

Table 5.10

Apps' Ratings

	Mean	SD	N
Cognitive Involvement	2.44	0.26	50
General pedagogical issues	2.43	0.27	50
Operational issues	2.33	0.33	50

Note. 1 = always, 2 = to some extent, 3 = never, and 4 = not applicable.

There are six detailed descriptions for cognitive involvement in appraising the Apps. Table 5.11 presents the percentage of each description in cognitive involvement. This shows that 98% of the Apps primary cognitive goal was "remembering". According to MAAS criteria (see Appendix L) "remembering" involves children being able to retrieve and review numeracy concepts, skills and procedures. In addition, to remembering, the second most common form of cognitive involvement was "understanding", which involves children demonstrating numeracy concepts, skills and procedures. Therefore, as could be expected with Apps designed to teach preschool numeracy skills, foundational skills of remembering and understanding were the most prevalent cognitive involvements.

Table 5.11

Detailed Descriptions for Cognitive Involvement (Percentage)

	Cognitive involvement (percentage)			
	1	2	3	4
Remembering	76.0	22.0	2.0	0.0
Understanding	30.0	48.0	22.0	0.0
Applying	0.0	42.0	58.0	0.0
Analysing	0.0	8.0	92.0	0.0
Evaluating	0.0	0.0	100.0	0.0
Creating	0.0	2.0	98.0	0.0

Note. 1 = always, 2 = to some extent, 3 = never, and 4 = not applicable.

5.5.3. Apps' General Pedagogical Issues

A variable "pedagogical" was created by adding ten items in general pedagogical issues and then being divided by 10 to calculate the 50 Apps' degree of general pedagogical issues when the researcher interacted with the Apps.

There were ten detailed descriptions for pedagogical issues in appraising the Apps. Table 5.12 presents the percentage of each description in pedagogical issues. These results indicate that the most noticeable pedagogical concerns were that children cannot pose their own questions and have no control over their learning, and there is no opportunity for collaboration.

Table 5.12

Detailed Descriptions for Pedagogical Issues (Percentage)

	Pedagogical issues (percentage)			
	1	2	3	4
Permits students to pose their own problems	0.0	2.0	98.0	0.0
Allows for differentiation through sequentially designed degrees of difficulty	32.0	46.0	22.0	0.0
Gives students control over their learning	4.0	18.0	78.0	0.0
Delivers content in an appealing and motivating way according to the age group	20.0	64.0	16.0	0.0
Provides meaningful teaching and learning guidelines	6.0	52.0	42.0	0.0
Integrates maths with content from other Key Learning Areas	12.0	24.0	64.0	0.0
Allows students to collect and record their own data	6.0	20.0	74.0	0.0
Shows a reading level appropriate to the student's level	50.0	26.0	24.0	0.0
Saves and keeps students' work	16.0	20.0	64.0	0.0
Provides opportunities for collaboration	0.0	2.0	98.0	0.0

Note. 1 = always, 2 = to some extent, 3 = never, and 4 = not applicable.

5.5.4. Apps' Operational Issues

A variable "operational" was created by adding ten items in operational issues and then being divided by 10 to calculate the 50 Apps' degree of operational issues when the researcher interacted with the Apps.

There are ten detailed descriptions for operational issues in appraising the Apps. Table 5.13 presents the percentage of each description in operational issues. When considering these

results in relation to the developmental capacities of young children there are clear areas that need to be addressed. For example, letting children/caregivers alter settings to meet developmental needs, and developers making Apps that can cross between an individual child or multiple children in group settings. Further research would be needed to validate if "operational issues" such as interfacing with social media tools are needed for children within the preschool years.

Table 5.13

Detailed Descriptions for Operational Issues (Percentage)

	Operational issues (percentage)			
	1	2	3	4
Has an intuitive and user friendly navigation	30.0	56.0	14.0	0.0
Contains helpful technical instructions to the user and/or a Help function	18.0	66.0	16.0	0.0
Lets students alter its settings to customise the app to their needs	18.0	44.0	38.0	0.0
Allows file sharing, streaming of content and/or online communications	0.0	0.0	98.0	2.0
Is flexible permitting students to move in different directions	4.0	6.0	88.0	2.0
Has a supporting Web page providing additional useful information	26.0	36.0	38.0	0.0
Easily works with a range of media (audio, video, image, text, animations)	4.0	16.0	80.0	0.0
Can interface with social media tools (e.g., Facebook, wikis, blogs, Twitter, YouTube)	20.0	2.0	78.0	0.0
Presents an uncluttered display which is visually stimulating	38.0	60.0	2.0	0.0
Permits a student leave at any time and begin where he or she left	18.0	32.0	50.0	0.0

Note. 1 = always, 2 = to some extent, 3 = never, and 4 = not applicable.

5.6 Variable "Cost2" and Areas in the GIARS

The variable "cost2" was created by categorising the prices of the chosen Apps into two groups: 0 = free, 1 = paid (from $0.99 to $5.49). The relationship between all the ratings among the areas and the Variable "cost2" were presented. It was found the ratings in the areas of "age appropriateness", "contextual environment", "scaffolding", "real world model" and "anatomy of a gesture" and the variable "cost2" were related significantly (see Table 5.14). Paid Apps rated higher than free Apps in meeting "age appropriateness", "contextual environment", "scaffolding", "real world model" and "anatomy of a gesture". These results

highlight that App quality is influenced by price, especially in terms of "age appropriateness". This relates to Apps using realistic concepts and appropriate methodologies within design.

Table 5.14

Variables and Cost2

Variable	Cost2		*t*	*df*	*p*
	Means of Free apps (*n* = 31)	Means of Paid apps (*n* = 19)			
• Age appropriateness	0.69	0.93	-3.67	48	0.001
• Contextual environment	0.50	0.75	-3.49	48	0.001
• Seamlessness	0.78	0.85	-1.04	47	*ns*
• Scaffolding	0.46	0.72	-3.29	48	0.002
• Non-violence	0.92	0.95	-0.49	48	*ns*
• Process orientation	0.31	0.46	-1.86	48	*ns*
• Real world model	0.73	0.92	-3.31	48	0.002
• The anatomy of a gesture	0.40	0.70	-3.28	48	0.002
• No touch left behind	0.87	0.97	-1.63	48	*ns*

5.7 "Cost2" and App ranking in MAAS

The relationship between all the ratings among the sections of cognitive involvement, general pedagogical issues and operational issues in MAAS and the variable "cost2" were presented. It was found the ratings in the sections of "cognitive involvement" and "operational issues" and the variable "cost2" were related significantly (see Table 5.15). Paid Apps were rated better than free Apps in meeting "cognitive involvement" and "operational issues". This result again highlights that price influences App quality, which could be due to the resources allocated to making the App and consequently need for reimbursement by the App designer.

Table 5.15

Four Sections in MAAS and Cost2

Four Sections in MAAS	Cost2		*F (1,48)*	*p*
	Means of Free Apps (*n* = 31)	Means of Paid Apps (*n* = 19)		
• Cognitive Involvement	2.50	2.35	4.28	0.04
• General Pedagogical Issues	2.48	2.35	2.93	*ns*
• Operational Issues	2.47	2.11	21.09	<.01

5.8 Apps used with Phase 3

The top five rated Apps within GIARS were chosen and in Phase 3 of the study, children's play phase. The five Apps were Bugs and Buttons, Count Bees, Intro to math, Monkey Math and Bugs and Bubbles. In order to compare the results between the examples of Apps and children's engagement in playing Apps, this section reports the characteristics and ratings from the GIARS and MAAS as well as price.

Although there was no difference between the ratings of the five Apps chosen, there were some minor differences within the areas in GIARS (see Table 5.16) and MAAS (see Table 5.17). All of the five chosen Apps were rated developmentally appropriate within GIARS and highlighted that they were predominantly 'instructive' in style, hence focusing on drill-and-practice styled learning. Further findings in relation to the children's playing will be reported in the following chapter.

Table 5.16

Total Rating and Each Rating in Different Categories of the 9 areas in GIARS

Apps	Total Score	Age Appropriateness	Contextual Environment	Seamlessness	Scaffolding	No Touch Left Behind	The Anatomy of A Gesture	Non-Violence	Process Orientation	Real World Model
Bugs and buttons	7.5	1	0.5	1	1	1	0.5	1	0.5	1
Bugs and bubbles	7.5	1	0.5	1	1	1	0.5	1	0.5	1
Count Bees	7.5	1	1	0.5	0.5	1	1	1	0.5	1
Intro to math	7.5	1	1	1	1	0.5	0.5	1	0.5	1
Monkey math	7.5	1	1	0.5	1	0.5	1	1	0.5	1

Table 5.17

Total Rating and Each Rating in Different Categories of MAAS

Apps	Explorative	Productivity	Instructive	Cognitive involvement	General Pedagogical issues	Operational issues
Bugs and bubbles	2.40	2.60	1.00	2.17	1.80	2.00
Bugs and buttons	2.40	2.60	1.00	2.17	1.80	2.00
Count bees	2.80	2.60	2.00	2.67	2.50	2.10
Intro to math	2.60	2.80	1.80	2.00	2.60	1.90
Monkey math	2.40	2.60	1.20	2.00	2.30	1.70

5.9 Summary

This chapter demonstrated that less half of the most popular Apps for children's numeracy learning were indeed developmentally appropriate. There were however, no Apps that scored within the highest ranges within the Gestural Interface App Rating Scale (GIARS). This chapter showed that price plays a factor in the quality of Apps as rated by GIARS and the Maths Apps Appraisal Scale (MAAS). The higher the price, the more developmentally appropriate the Apps are. Eighty percent of the Apps reviewed were either free or cost less than $1.00.

In GIARS, the majority of Apps were rated as skill drilling rather than discovery learning. Apps within the study were predominantly categorised as Instructive Apps, as rated within MAAS. Furthermore the primary cognitive goal of the Apps according to MAAS was for children to "remember" and "understand" numeracy concepts, which is consistent with expectations for numeracy development within the early years. The primary issues identified within Apps relating to cognitive engagement is that children had very little control over their learning, could not pose their own questions and that there is little room for collaboration. Additionally, GIARS showed that roughly only 50% of Apps used appropriate teaching pedagogies, however for the most part, Apps provided children with sound learning objectives.

In relation to interface and gameplay, as identified by MAAS and related to criteria within GIARS, there were a number of areas that identified quality Apps, such as allowing educators/parents to alter developmental settings within the Apps to meet the capacity of the child. Other traits of developmentally appropriate Apps included that they had clear beginnings, which leads children into what they can expect in terms of gameplay and interface use. Within the study, many Apps used a minimal number of interface elements, which responded to every contact, allowing children to focus on the content of the game, rather than being confused by complicated interface controls. Additionally, Apps were generally smooth within transitions and limited the number of cut sequences and time based gestures. However, Apps need to scaffold children more effectively through their gestures, as this study found that Apps often use text-based instructions for pre-reading children. In addition, children need to have the option to reverse actions once started.

The top five Apps rated from the Gestural Interface App Rating Scale were used in the children's playing phase, these being Bugs and Buttons, Count Bees, Intro to Math, Monkey Math and Bugs and Bubbles. All the five chosen Apps were rated developmentally appropriate for young children within GIARS and were classified as Instructive Apps in MAAS. The children had the freedom to choose from these five Apps when they were playing. The results are reported in Chapter 6.

Chapter VI: Findings of Child Play Phase

6.1 Introduction

This chapter builds on the results from Phase 1 and 2 and presents the results of Phase 3: children's play phase. The chapter addresses the research questions: *to what level do 3-4 year old children engage, enjoy, and learn numeracy concepts via play with gestural interface devices?*

The chapter details the findings of the observations conducted in the child care centres in the following order: (a) demographic characteristics of sample, (b) children's engagement in playing the Apps, (c) children's numeracy abilities, (d) children' playing and the chosen Apps, (e) children' interaction with other children while playing with the Apps, (f) children's enjoyment in playing, (g) other factors that influence children's App use, (h) factors from educators and parents in relation to numeracy improvement (i) children's engagement in playing with Apps and their demographic background, and (j) children's numeracy improvement compared with children's other factors during App use.

6.2 Demographic Characteristics of Sample

Of the 80 children, 44 (55%) were male, and 36 (45%) were female. Forty (50%) children were from South Australia, and forty (50%) were from the Northern Territory. The age range of the children was from 36 months (above 3 years) to 59 months (under 5 years old). Children were classified as 3-4 years age group (43.8%), and 4-5 years age group (56.3%). Therefore there is an even spread of children between the two primary age ranges which represent a variety of differing developmental capacities as attaining to ages and stages of development.

Of the 80 children, 12 children (15%) were attending child care centre(s) full time (10 sessions per week), 68 children (85%) were attending child care centre(s) between 4 sessions to 8 sessions (see Figure 6.1).

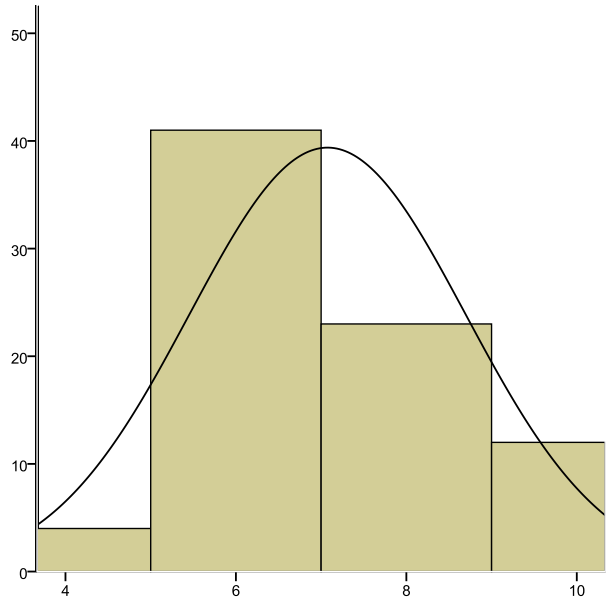

Figure 6.1. Children's sessions per week.

6.3 Children's Engagement in Playing the Apps

This section details children's engagement whilst playing Apps based on the Engagement Scale (DECS, 2008) in the nine areas of concentration, energy, complexity and creativity, facial expression and posture, persistence, precision, reaction time, verbal utterances and language, and satisfaction. Table 6.1 presents the means and standard deviations of the nine areas. It was found almost all the areas other than verbal utterances and language were rated above medium engagement. Among them, the areas facial expression and posture, persistence and concentration were rated closer to high engagement. A repeated measures ANOVA was applied across the nine frequencies. A significant effect was evident (see Table 6.1). This suggests that all areas in engagement scale were discriminating effectively between the items. This indicates that the nine areas are interrelated therefore engagement with digital technologies is a holistic process for children.

Table 6.1

Engagement of Children's Playing Apps (Means)

	Mean	*SD*	*N*
Facial expression and Posture	2.90	.47	80
Persistence	2.83	.50	80
Concentration	2.80	.47	79
Reaction time	2.50	.57	80
Precision	2.39	.65	80
Satisfaction	2.26	.51	80
Energy	2.23	.50	80
Complexity and Creativity	2.05	.37	80
Verbal utterances and Language	1.79	.64	80

Note. (a) The means are presented in order, from highest to lowest, using 4-point scale anchored (0 = no engagement, 1 = low engagement, 2 = medium engagement, and 3 = high engagement). (b) A repeated measures ANOVA on the above means revealed a significant effect, F (8, 624) = 90.17, $p < .01$.

Figure 6.2 shows that facial expression and posture was rated the highest and verbal utterances and language was rated the lowest. This result highlights the social concerns that early childhood educators have towards the integration of digital technology into early childhood environments, in that children have less verbal communication when engaged in play with technology.

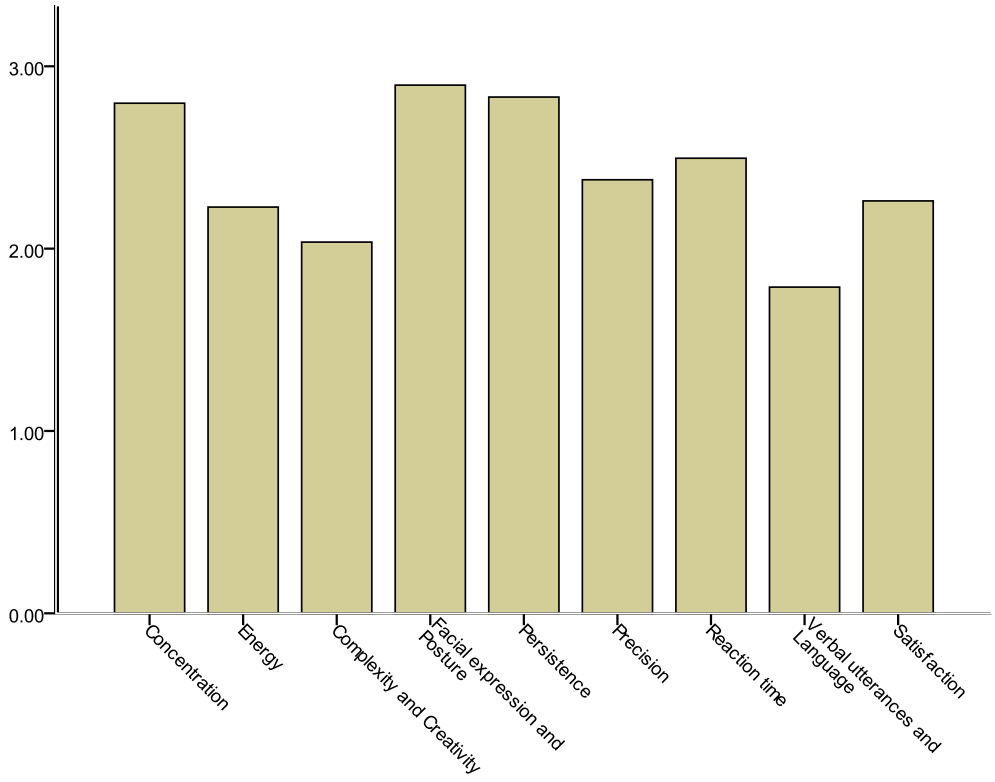

Figure 6.2. Means of ratings of concentration, energy, complexity and creativity, facial expression and posture, persistence, precision, reaction time, verbal utterances and language, and satisfaction.

General ranking in each observation were also rated from 0 (no engagement) to 5 (high engagement) in children's engagement. General ranking was rated 6 times per child. The mean of general ranking for all the children was 3.71, and the standard deviation was .87. It was of interest to explore whether there was an improvement for the children in their general ranking from the first observation to the last observation to determine if engagement was sustained over the observations. It was found that there was no significant improvement between the first observation and the last observation, p = ns. However, there were some minor differences among the general ranking over 6 observations (see Figure 6.3). These results indicate that overall there was a consistently high level of engagement from the first observation to the last, therefore children's engagement did not decrease after initial exposure to the device; rather it increased.

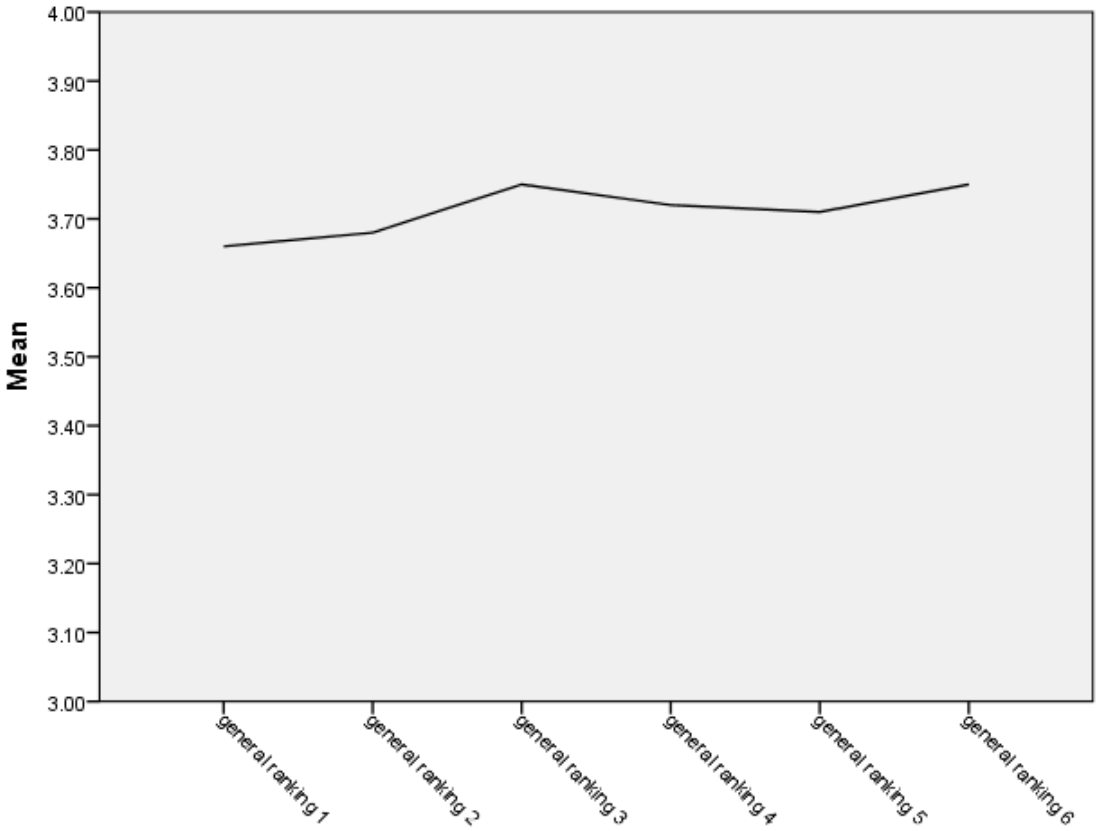

Figure 6.3. Means of general ranking of six observations.

6.4 Children's Numeracy Abilities

Based on Ramani and Siegler's (2011) and Segal's (2011) studies, children's numeracy abilities were tested in the five areas of: (a) numeral identification, (b) counting, (c) arithmetic problems, (d) shape identification, and (e) patterns. Children were asked to count as high as they could in the counting test. In numeral identification, the children were asked to identify numbers 1-10. In the area of shape identification, children were asked to identify 10 shapes. In the area of arithmetic problems, children were asked to answer four problem questions. Finally children were asked to identify two patterns. The tests were undertaken before and after children's App play.

Paired sample t-tests were run to compare the means between pre-test and post-results in the five areas of children's numeracy abilities (see table 6.2). To avoid the assumption of normal distribution, a Wilcoxon signed-rank test was also conducted. Table 6.2 shows that children's numeracy abilities were significantly different between pre-test results and post-test results in all of the five areas. This finding was one of the most important results of the study. This result clearly demonstrates that children learnt numeracy outcomes whilst engaged with the iPad over a two-week observation period. It confirms parents and educators assertions (see Chapter 4) that digital technology can be used to teach children numeracy learning outcomes. In addition, the Apps used in the Phase 3 were classified as developmentally appropriate in Chapter 5 and have translated to significant numeracy learning for 3-4 year old children.

Table 6.2

Pre-test and Post-results in the Five Areas of Children's Numeracy Abilities

Variable	Children's numeracy abilities		*t*, *df (79)*	Wilcoxon signed-rank test (Z)	*p*	*d*
	Means of Pre-test results (N = 80)	Means of Post-test results (N = 80)				
Counting	13.7	15.26	5.02	-5.27	< .01	0.19
Numeral identification	5.60	6.11	5.55	-4.56	< .01	0.16
Shape identification	4.14	4.65	5.07	-4.63	< .01	0.31
Arithmetic problems	3.12	3.51	5.65	-4.44	< .01	0.38
Patterns	0.61	1.31	9.17	-6.29	< .01	0.92

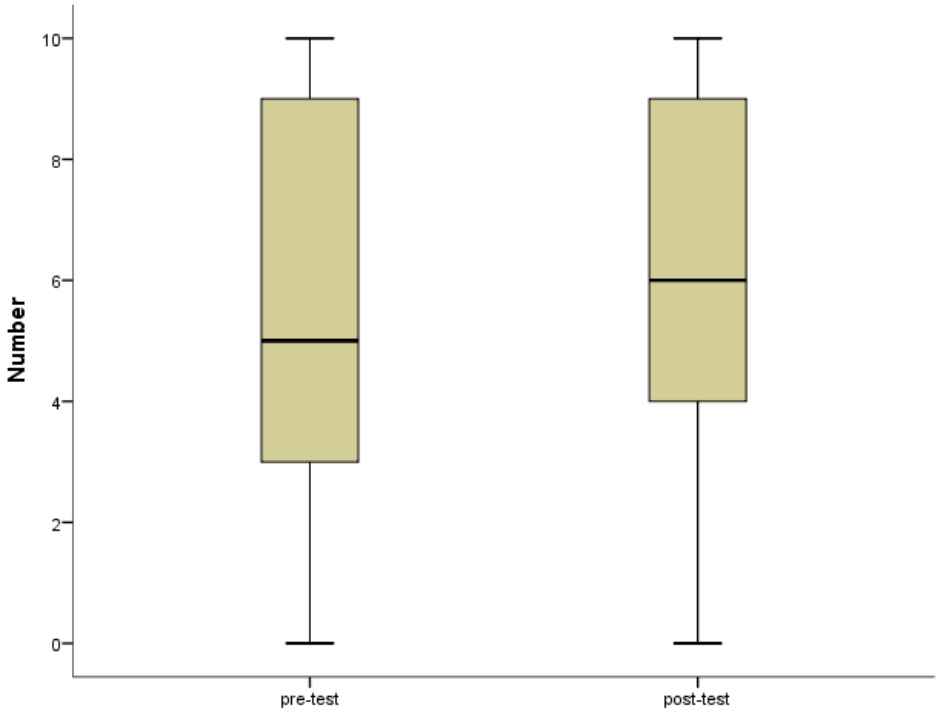

Figure 6.4. Comparison of children's numerical identification in pre and post-test.

The boxplot (see Figure 6.4) shows most of the children improved significantly in numerical identification. Although the lowest (0) and the highest results (10) did not change, the group of children, in particular, whose initial results ranged between 3 and 4, improved to 4, resulting in the average improving from 5.60 to 6.11.

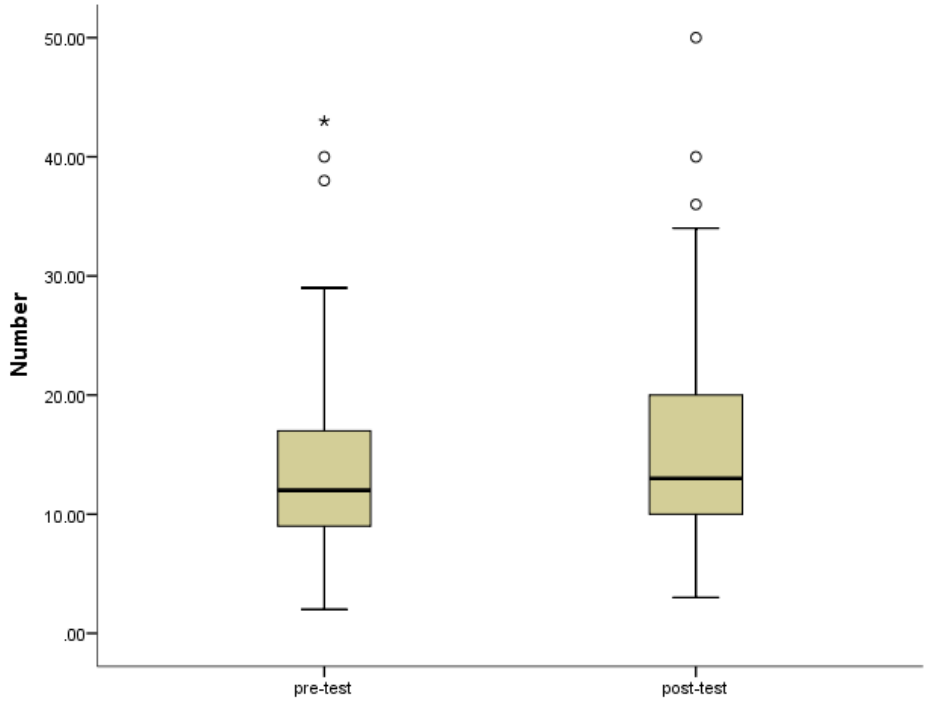

Figure 6.5. Comparison of children's counting ability in pre and post-test.

Figure 6.5, shows that every child in this study improved in their counting abilities. The 95% of the children who scored between 3 to 29 in the pre-test, improved to 4 to 34 in the post-test. In particular, two children's counting abilities improved significantly from around 40 to 50.

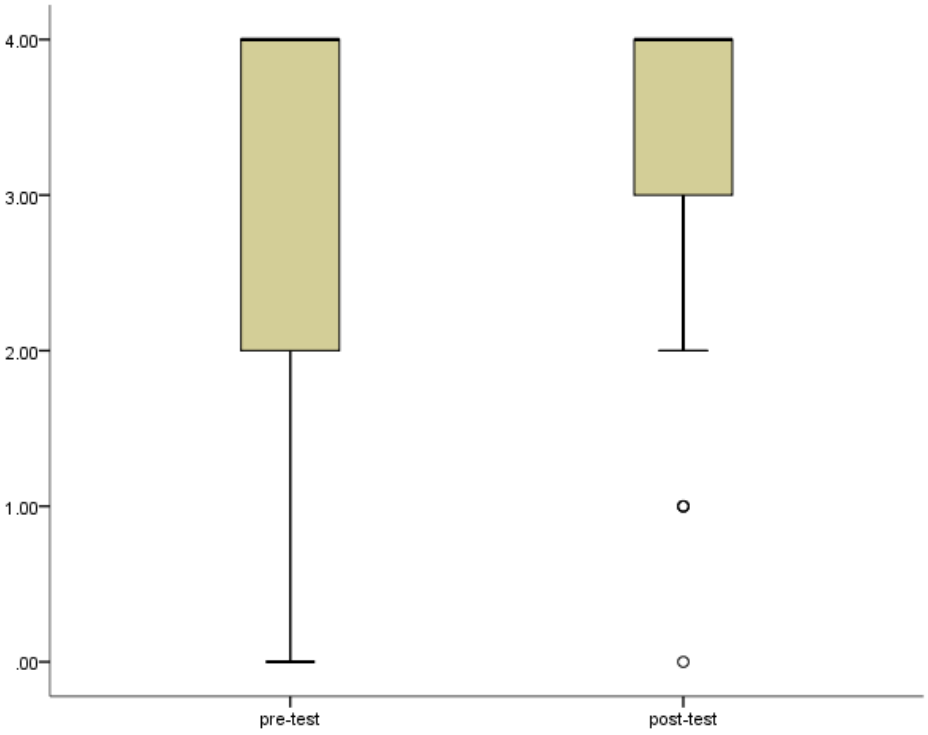

Figure 6.6. Comparison of children's arithmetic problem solving in pre and post-test.

Figure 6.6 demonstrates that the majority of the children (95%) improved in their arithmetic problem solving abilities from the pre-test to the post-test. Some children in the pre-test, who could not solve any problems, developed their abilities to solve two problems. It was noted that four children's problem solving skills did not change.

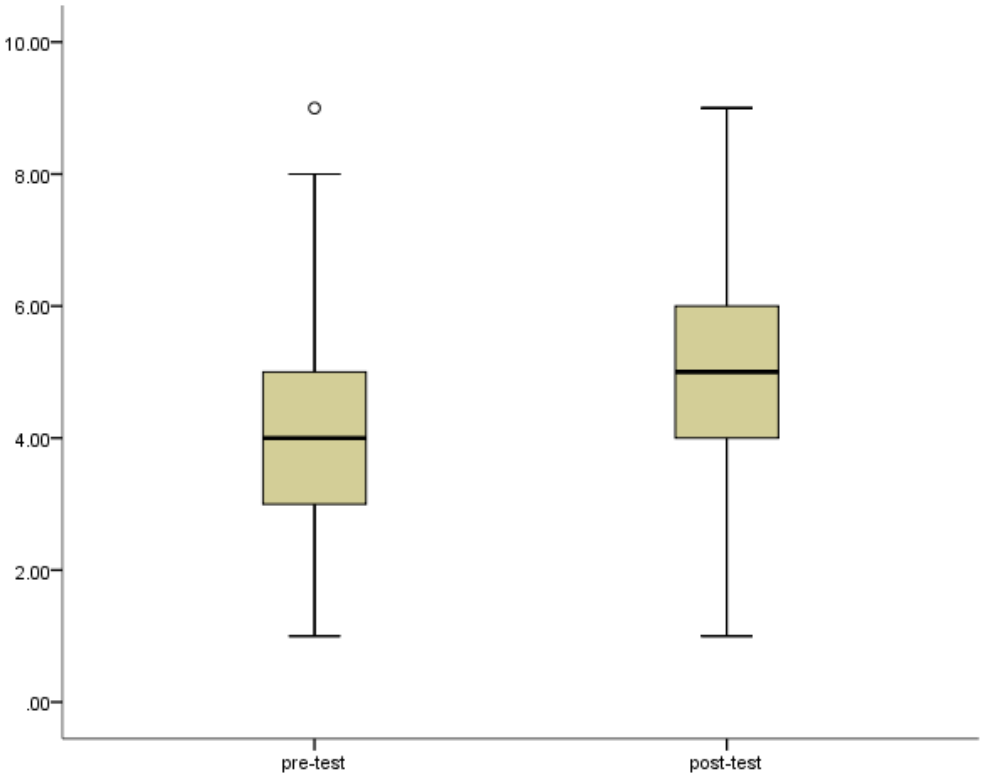

Figure 6.7. Comparison of children's shape identification in pre- and post-test.

Figure 6.7 shows that 50% of children improved in their shape identification skills. Although the lowest (1) and the highest results (9) did not change, the group of children, in particular, whose results ranged between 3 and 5, improved to 4 to 6 resulting in the average improving from 4.14 to 4.65.

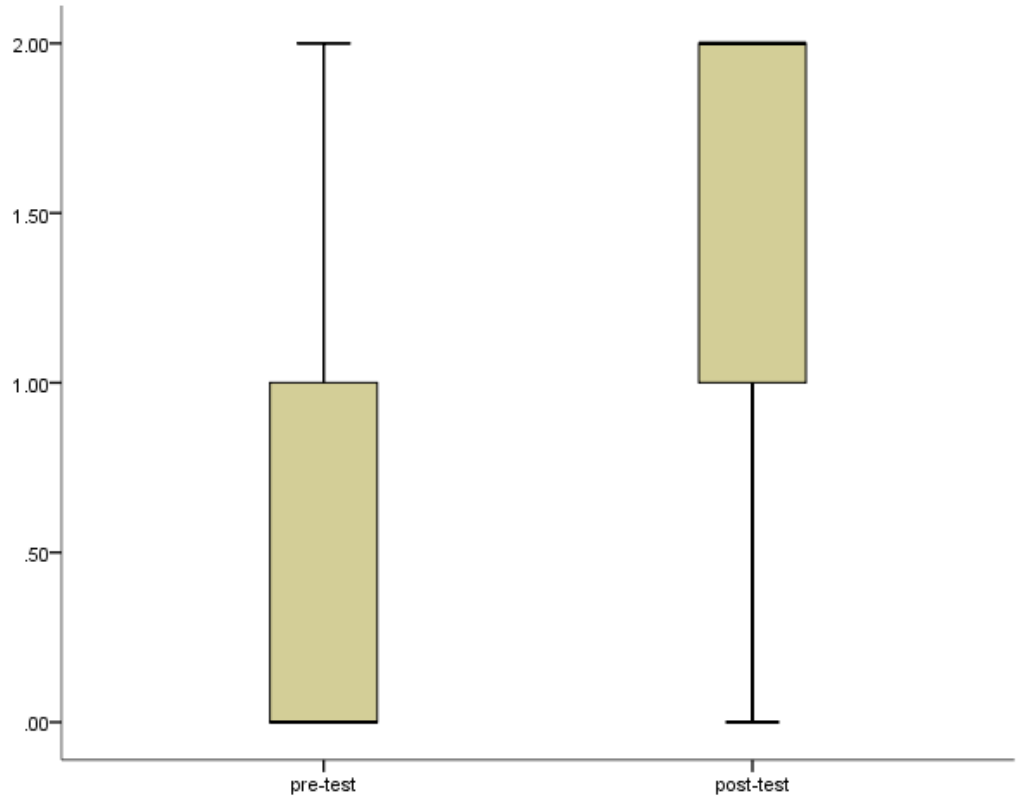

Figure 6.8. Comparison of children's pattern identification in pre- and post-test.

Figure 6.8 shows a significant change in children's abilities in pattern identification. In the pre-test, most of the children (97%) could either identify one pattern or none at all, whereas in the post-test, the majority of children (97%) could identify at least one pattern.

Wilcoxon signed-rank test was again used to compare the means of pre-test and post-test results in each participating child care centre. It was shown that the improvement of children's numeracy abilities happened in each participating child care centre in Table 6.3, Table 6.4 and Table 6.5.

Table 6.3

Pre-test and Post-results in the Five Areas of Children's Numeracy Abilities in Child Care Centre A

Variable	Children's numeracy abilities			
	Means of Pre-test results (n = 20)	Means of Post-test results (n= 20)	Wilcoxon signed-rank test (Z)	*p*
Counting	13.90	15.45	-3.05	< .01
Numeral identification	5.55	6.25	-2.56	0.01
Shape identification	4.35	5.05	-3.07	< .01
Arithmetic problems	3.05	3.65	-2.59	0.01
Patterns	0.85	1.50	-2.92	< .01

Table 6.4

Pre-test and Post-results in the Five Areas of Children's Numeracy Abilities in Child Care Centre B

Variable	Children's numeracy abilities			
	Means of Pre-test results (n = 20)	Means of Post-test results (n = 20)	Wilcoxon signed-rank test (Z)	*p*
Counting	12.70	14.85	-2.92	< .01
Numeral identification	5.30	6.15	-2.71	< .01
Shape identification	3.85	4.80	-3.17	< .01
Arithmetic problems	3.25	3.75	-2.76	< .01
Patterns	0.70	1.55	-3.49	< .01

Table 6.5

Pre-test and Post-results in the Five Areas of Children's Numeracy Abilities in Child Care Centre C

Variable	Children's numeracy abilities			
	Means of Pre-test results (n= 40)	Means of Post-test results (n = 40)	Wilcoxon signed-rank test (Z)	*p*
Counting	14.10	15.37	-3.25	< .01
Numeral identification	5.78	6.02	-2.89	< .01
Shape identification	4.18	4.37	-2.31	0.02
Arithmetic problems	3.10	3.43	-3.15	< .01
Patterns	0.45	1.10	-4.40	< .01

6.5 Children's Interaction with Other Children whilst Playing with the Apps

When children were playing with the Apps, other children involved within the study (up to nine children) were interacting with them. Table 6.6 presents the mean and standard deviation of the number of children who were interacting with the participants. When the children were playing, there were, on average, four other children interacting with the participants. This result shows that throughout the study children were engaged with other children during play with iPads. This result helps to allay concerns raised by educators and parents within Chapter 4 that digital technology is a socially isolating experience for children. Types of interactions children had with each other are noted and categorised within other factors influencing children's play (see Section 6.7).

Table 6.6

Mean and Standard Deviation of the Number of Children Who Were Interacting with the Participants

	Mean	*SD*	*N*
Number of children Interacting with the participants	4.15	1.43	80

6.6 Children's Enjoyment in Playing

Enjoyment was measured pre- and post-exposure to playing with the iPad. A paired sample t-test was run to compare the means between the pre-test and the post-results in relation to the five toys (iPad, reading, painting, play dough and xylophone). These were ordered by children from the toy that they would most like to play with, to the least. The iPad rated significantly higher in the post-test result than in the pre-test (see Table 6.7). There is consensus (Blythe et al., 2005; Kucirkova et al., 2014) that digital technology is an activity that children enjoy doing and this result confirms that after use, children wanted to continue playing the iPad and 'favourited' the activity significantly more after use than before.

Table 6.7

Pre-test and Post-results in Children's Enjoyment in Playing

Variable	Children's enjoyment		*t, df (79)*	*p*	*d*
	Means of Pre-test results (N = 80)	Means of Post-test results (N = 80)			
iPad	2.85	1.54	7.36	< .001	0.94
Reading	3.39	3.64	1.64	ns	ns
Painting	2.61	2.95	2.27	.026	-0.26
Play dough	3.05	3.46	3.08	.003	-0.35
Xylophone	3.10	3.43	2.25	.027	-0.25

Note. The toys were ordered by children from most like to play to least (1 = favourite toy, 5 = least favourite toy).

6.7 Other Factors that Influence Children's App Play

One of the tasks in completing the engagement scale for the researcher, was to write down the observations when the participants were playing, and they were classified into the following categories.

Factor 1: Use of trial and error

Factor 1 was categorised if the child was randomly selecting answers on the screen to find the correct answer instead of using appropriate numeracy comprehension or elements of the

gestural interface. The following text shows an example of use of trial and error:

Child No.28 was playing the App Bugs and Buttons. The App was asking Child No.28 to point to the bugs on the screen one by one. There were 3 bugs on the screen. Every time after the child pointed to a bug, the App would count the number: 1, 2 and 3. After all the 3 bugs on the screen were touched, and the playing child was asked to choose the correct total number of his counting (number 3) out of the five choices provided by the App on the screen. The choices were 1, 2, 3, 4, and 5 placed vertically down the screen. Instead of choosing number 3, he quickly started at the top of the screen and chose the number 1, receiving a cross (error message), pressed 2, also receiving a cross and finally three, receiving a star (answer confirmation). This behaviour was repeated in the following attempts at the same game whereby he would start at the top of the multiple choice answer screen and work his way down until he got the correct answer. Child No.28's pre-test numeral results indicated that he did indeed know what the number looked like, but instead of using his understanding of number, he used a trial and error approach to solve the problem.

The following is example of a child who *did not* do use of trial and error:

Child No.12 was also playing the App Bugs and Buttons. The App presented a series of 4 moving bugs on the screen which suddenly stopped, Child No.12 pointed at each bug on the screen and the App counted as the child pointed. After all the 4 bugs on the screen were counted, and the playing child was asked to choose the correct total number of his counting (number 4) out of the five choices provided by the App on the screen. Child No.12 chose the number 4 without pointing to the other numbers. The child repeated this behaviour in the following attempts, his response time was not as quick as Child No.28 (in the previous example) and occasionally he chose the incorrect response. Yet he did not appear to use trial and error, rather used his understanding of numeral identification to answer the problem.

Factor 2: Used elements of gestural interfaces (GI)

Factor 2 was categorised if the child attempted to use elements of the gestural interface to assist with the cognitive load of answering the numeracy question. The following text shows an example of the Use Elements of Gestural Interfaces (GI):

Child No.7 was playing the App Monkey Numeracy. The App asked Child No.7 to complete a pattern: shell, jellyfish, shell, jellyfish, shell …Child No.7 pointed at each sea character in the question (the App calls out the name of the object), then she pressed the three alternative answers provided at the bottom of the screen: shell, jellyfish and clam (again the App calls out the name of the object). Child No.7 then repeated the question again pushing the three shells and two jellyfish, she finally placed her finger on the middle answer (jellyfish) and dragged it into the answer box. This indicated that Child No.7 was able to use the gestural interface elements to assist in solving the numeracy question posed of her.

The following presents an example of a child who did not use elements of GI:

Child No.63 was also playing the App Monkey Numeracy. The App asked Child No.63 to solve the equation of 1+2. It provided Child No.63 with a set of sea horses that the child could count in order to assist with the cognitive load. At the bottom of the screen were three potential answers: 3, 5 and 2. Instead of using the sea horses to count, Child No.63 placed her finger on the number 5 and dragged it into the answer box, when the App made an error noise and reversed the action; Child No.63 placed her finger on the number 3 and dragged it into the answer square receiving an affirmative response from the App. Therefore, the child did not use the gestural elements provided by the App to assist with the cognitive load, rather she used a trial and error approach or conversely she believed she already knew the answer, thus not needing the gestural interface cues.

Factor 3: Other children initiate involvement in play

Factor 3 was categorised if children who were non-participants attempted to engage participants about the game being played. The following text shows an example of the other children initiating involvement in play:

Child No.23 was playing the App Monkey Numeracy. The App asked Child No.23 to connect the dots from number 1 to the number 7. The participant needed to touch 1 and then drag a line to the number 2, to 3 and so on moving along until they finish at 7 (at which point a turtle traverses the path created and calls out the numbers). Child No.23 was struggling to use the interface and appeared not to understand that there was a need to drag from one number to another; he was touching 1 then touching 2 without using a drag function, then would touch the turtle then touch a number. A child sitting next to Child No.23 reached out to the iPad, placed his finger on number 1 then dragged the line to number 2 and said That's how you do it and smiled at Child No.23. Child No.23 did not acknowledge the assisting child by looking or saying anything, instead proceeded to drag the line from 2 to 4, again negating the movement of the turtle as he skipped the number 3. He did this three times (if the attempt is incorrect the app negates the line and moves it back to its previous place, in this case back to 2). Again, the assisting child reached in and dragged the line from 2 to 3, looked at Child No.23 who nodded his head, the assisting child then proceeded to finish the game. Therefore without being asked, the assisting child initiated involvement during Child No.23's play.

Factor 4: Other children distract play through initiating other activities

Factor 4 was categorised if children were participating in a game and there was an attempted to distract them with information not pertaining to the game or iPad use. The following text shows an example of an ignored distraction:

Child No.17 was playing the App Bugs and Bubbles. The child was positioned inside the child care centre. Another boy came running up to Child No.17 from the outdoor environment and said Child No.17 come to the

sandpit we've built a monster hole. Child No.17 looked in the other child's direction and replied Yeah, I'll be there when I finish my game and turned his attention back to the iPad and continued playing the game.

Factor 5: The player involves other children in playing

Factor 5 was categorised if children were participating in a game and there was an attempt to engage another child in their game by making the first advance. Observation of the child No. 21 shows an example of the player involving another children in play:

Child No.21 was playing the App Intro to Numeracy. The child was sitting at a table with the iPad in front of her. The game that Child No.21 was playing was a numeral copying game, she was attempting to trace the number 4. Child No.21 had only completed half of the tracing of the number 4 and the App was prompting her to finish moving across the screen to complete the horizontal stroke, however she was attempting to move down the screen vertically to finish the number (the App will not let the participant move forward until the numeral is completed). Child No.21 appeared quite frustrated and looked at an older child standing near her and said I can't do this, can you help me and moved the iPad closer to him. The older child looked at the screen for about 5 seconds (the App was still prompting the participant to move across the screen), he then completed the task and the App moved to the number 5. The older child smiled at Child No.21 and moved the iPad back in her direction, Child No.21 smiled back and said Thanks! In this case Child No.21 sough the assistance of the older child to solve a problem she was having.

Factor 6: The player distracts other children during playing

Factor 6 was categorised if the child was using the iPad and during their play discussed non-iPad related information with another child. Observation of the child No. 52 shows an example of the player distracting another child during play:

Child No.52 was playing the App Bugs and Bubbles. The child was sitting at an outside bench with an iPad in front of him playing a game. A child rode a bike past the bench where Child No.52 was using the iPad. Child No.52 looked up from his game and said to the child on the bike hey, that's my bike. The child on the bike looked back at Child No.52, put his feet on the ground and asked can I use it Child No.52. Child No.52 replied okay, but once I've finished this I want it back. Child No.52 returned to the game he was playing and the child on the bike rode away.

Factor 7: The player ignores other children's engagement

Factor 7 was categorised if the child was using an iPad, and during their play another child attempted to interact with the child regarding game play or iPad use, and the child did not appear outwardly to acknowledge the child's attempted engagement. Observation of the child No. 24 shows an example of the player ignoring another children's engagement:

Child No.24 was playing the App Counting Bees. She was sitting at a table, with a book case to her left and in front of her, to her right, was Child No. 37 who was watching Child No.24 play. Child No.24 was watching the bees float across the page, she did this for about 10 seconds when Child No.37 looked at Child No. 24 and said you have to move the bees to the flowers, do you want me to show you? Child No.24 did not look at or say anything to Child No.37 and continued to watch the bees; Child No.37 reached in and moved one of the bees towards the flower, causing the App to call out 1. Child No.24 again did not acknowledge Child No.37's actions nor touched the screen. Child No.24 then pressed the 'home button' on the iPad and exited the Counting Bees game.

Factor 8: The player stopped other children's interruption

Factor 8 was categorised if the child was using an iPad and during their play another child attempted to interact with the child and the child verbally requested the interacting child to stop their interruption. Observation of the child No. 32 shows an example of the player stopping other children's interruption.

Child No.32 was playing the App Bugs and Buttons. The child was sitting at an indoor table with a cupboard to her left. In front of her was another child at a table using a second iPad, and to her right was another child, who was watching her play. Child No.32 was playing a game in which the participant had to correspond numerals to number patterns. In the game there was a beetle with a numeral (e.g. 4) on his shell and three corresponding boxes with decoration number patterns (e.g. 2, 4 and 6). The child has to select the box with the pattern of 4 and drag the box to the beetle, hence completing the task. Child No.32 was having difficulty with the task both in terms of how to drag and also the counting component of the task (she made many errors). After 2-3 minutes of playing the game with repeated failures, the child watching Child No.32 reached in and dragged the appropriate box and smiled at Child No.32. Child No.32 glared at the assisting child and pulled the iPad closer to herself. Again Child No.32 struggled with the game, again the child attempting to assist reached in to help Child No.32. At this point Child No.32 pushed the child's hand away and said no, this is my turn, the assisting child pulled her hand back and continued to watch Child No.32. Hence, regardless of the assisting child's intentions, Child No.32 stopped the potential interaction.

Factor 9: The player's private speech during playing

Factor 9 was categorised if the child was using an iPad and during their play used private speech. Observation of the child No. 71 shows an example of this:

Child No.71 was playing the app Bugs and Bubbles. The child was playing a pattern game in which a series of bubbles appears (e.g. yellow, red, yellow, blank) and then a set of three potential answers appears (orange, green, red) and the player has to drag the correct answer to the blank bubbles. Child No.71 was saying the colours out loud: yellow, red, yellow…[he reached up and dragged the red bubble to the blank space and said:]

…red! On the next set [blank, purple, orange, purple] he began by repeating the colours purple, orange, purple, then he put his fingers on the potential answers (orange, purple, blue) and said noooo…yes and proceeded to drag the blue bubble to the blank space, which received an error message. He then put his fingers back to the answer buttons and verbalised the colours orange, purple, blue, this time he dragged the orange bubble down, which triggered the next set, to which Child No.71 called out yes. Private speech is self-directed speech that is intended to guide thinking and behaviour (ref), which is what Child No.71 demonstrated in this example.

Factor 10: The player seeks software support during playing

Factor 10 was categorised if the child was using an iPad and during their play asks for assistance with software support in terms of how to start or how to play an App (not how to solve a numeracy problem or use the physical features of the iPad). Observation of the child No. 5 shows an example of the player seeking software support:

Child No.5 was sitting on the floor with two children sitting either side of him, he had opened the App Counting Bees. Child No.5 looked at the screen for a 5-10 seconds, turned to the child to his left and asked what do you do? The child responded press the green button. Child No.5 pressed the button and watched as the game began and the bees began moving over the screen. He looked at the same child who had answered his initial question and again asked what do you do? The App then illustrated to the child that he needed to drag the bee to the flower, upon which Child No.5 dragged the bee to the flower without waiting for the assisting child to answer. Hence, Child No.5's question was about software support rather than hardware or numeracy reasoning.

Factor 11: The players seeks staff member's assistance

Factor 11 was categorised if the child was using an iPad and during their play asked a staff member (not the researcher) for assistance with any element of use or play. Observation of the child No. 15 shows an example of the child seeking a staff member's assistance:

Child No.15 was sitting on the floor with 3 children sitting in front of him. He was playing the App Bugs and Buttons. Within that App, Child No.15 was playing the game Roach Racing. In this game the participants have to tap the buttons in a pattern order to make the cockroach move faster as it races against other cockroaches. The game starts with a race countdown and then the cockroaches begin to move, Child No.15 did not know what to do and subsequently his cockroach did not move as the other cockroaches raced away. Child No.15 looked at the screen for about 10 seconds and looked at a passing caregiver and said Miss Caregiver can you help me, the caregiver responded Sure Child No.15. The caregiver sat down with Child No.15 and looked at the screen and said what do you have to do here, Child No.15 said I don't know? After looking the screen for about 15 seconds the caregiver said the game is telling you to touch the buttons to make the beastie move. Child No.15 began touching the buttons in the pattern order and in turn the cockroach moved up the screen. The caregiver stood up and said Mmm, doesn't look very educational to me and proceeded to walk away. This was the only occasion

during the entire study in which a child asked a caregiver for assistance with any form of interaction with iPad use.

Factor 12: The player terminates the game

Factor 12 was categorised if the child was using an iPad and during the observation period and stopped playing, left the game and did not return within the allotted observation time. Observation of child No. 18 shows an example of the child terminating the game:

Child No.18 was inside playing the App Counting Bees. He was struggling in terms of controlling the gestural interface and appeared to find it very difficult to control where the bees moved on the screen. Twenty seconds into the observation Child No.18 stood up and ran outside, he did not say anything and did not return to the activity. He was the only child who left during an observation period.

Factor 13: Struggled using fine motor skills in GI

Factor 13 was categorised if the child was using an iPad and appeared to be struggling to use elements of the gestural interface due to fine motor control issues. This includes precise selection of content, icon selection and dragging and dropping features. Observation of child No. 9 shows an example of a child struggling to use the GI because of her fine motor skills:

Child No.9 was inside at a table playing the App Monkey Numeracy. She had no children watching her. The game asked her to complete a number sequence: 1, 2, blank, 4, 5. At the bottom of the page were three possible options: 5, 4, 3. Child No.9 put her finger on the number 5 icon and appeared to be pressing down very firmly as her finger was vertical rather than angled towards the screen. She moved it up towards the blank space (she did this very slowly compared to many of her peers). As she was dragging the number five she lifted her finger causing the 5 to drop to its original location, she did this 3 times. On the fourth attempt she was able to drag the 5 to the box upon which the App gave her a failed attempt sound. She then looked at the game for 5 seconds and moved her finger to the number 4 icon in the answer section, again dragged the icon very slowly towards the blank space and again dropped it twice, on the third attempt she got the failed attempt sound from the App. She immediately moved to the number 3 icon and slowly dragged it towards the blank space, again she dropped the icon twice. On the third attempt she dropped the icon into the blank space initiating the Apps success sound and moving her to the next game. Child No.9 was having difficulty dragging. The game itself is quite forgiving in terms of icon selection (your finger does not need to be exactly on the icon) and as long as you drop it close to the answer square it will complete the action. For every observation of Child No.9 it was noted that she had fine motor control issues.

Factor 14: The player seeks hardware support during play

Factor 14 was categorised if the child was using an iPad and asked for information directly related to using the physical features of the iPad itself from the researcher, staff or peers. Observation of child No. 3 shows an example of the child seeking hardware support:

Child No.3 was sitting on the floor inside. It was his turn to use the iPad and the child who was previously using the iPad turned it off and passed it to Child No.3. Child No.3 took the iPad, looked at it for 5 seconds then asked the researcher: how do I turn it on? The researcher showed Child No.3 where the on/off button was located and Child No.3 clicked it. Once powered, Child No.3 was able to swipe the unlocking icon to open the home screen. In this case Child No.3 needed hardware support as he did not know how to turn the iPad on.

Factor 15: The player seeks numeracy support during playing.

Factor 15 was categorised if the child was using an iPad and asked a peer, staff member or researcher for assistance to solve a numeracy problem. Observation of child No. 43 shows an example of the child seeking numeracy support.

Child No.43 was outside at a bench playing the App Monkey Numeracy, he had a child either side of him and the researcher was sitting at the bench across from him. The game verbally asked Child No.43 to find the shape with 5 sides, the App then gave the child a choice of a square, a pentagon and a triangle. Child No.43 looked at the shapes for about 10 seconds, his finger hovered over the square icon, he looked at the researcher and asked: which shape has five sides? The researcher replied to Child No.43: I'm not sure, what do you think? Child No.43 continued to hover with his finger over the square then he verbally began counting each side of the square 1, 2, 3, 4… Child No.43 looked at the researcher again and asked: Is it this one [pointing at the pentagon]? To which the researcher replied: I'm not sure, what do you think? Child No.43 then counted the sides of the pentagon 1, 2, 3, 4, 5…, then he pressed the pentagon icon. The App then gave feedback stating that it was a pentagon that has five sides and counted the sides, after which Child No.43 nodded and said see.

The frequencies of the factors were counted by the researcher when the children were playing with the Apps. Table 6.8 presents the means and standard deviations for each factor. The findings show that the predominant factor that the children used was trial and error. As shown in Section 6.4, children did actually improve their skills whilst using the Apps over the Play Phase and therefore the use of trial and error appears to be productive in terms of children's learning. The second most common observation was that children watching others use iPads initiated interactions with participants regarding gameplay. This result indicates that digital technologies have the potential to be a social experience for children and that children are

interested in sharing ideas and thoughts regarding content, hence a level of collaboration is seen within use.

Two other factors observed by the researcher was that three of the five lowest recorded observations were related to children not asking for assistance with either the use of hardware or software. This result indicates that using a gestural interface is an appropriate teaching tool for young children as they were able to operate the tools with minimal support. However, whilst they are able to operate the hardware and software, the third most common observation was children struggling with elements of the gestural interface due to fine motor control issues. Whilst this may seem counterintuitive with the previous statement of children not asking for assistance, this shows that children, despite fine motor issues, are willing to persevere through difficulties to continue playing the Apps. Hence children are refining motor skills leading to higher outcomes (Harwood et al., 2008). Fine motor control was also linked to children's age (see Section 6.9.2).

Table 6.8

Fifteen Factors Observed by the Researcher in Children' Playing

	Mean	*SD*
Factor 1	4.59	1.89
Factor 3	3.43	1.55
Factor 13	2.60	2.58
Factor 7	2.16	1.75
Factor 5	1.96	2.08
Factor 2	1.89	2.10
Factor 15	1.49	2.21
Factor 8	1.26	1.39
Factor 4	1.02	1.25
Factor 9	0.97	1.92
Factor 10	0.90	1.25
Factor 14	0.56	0.98
Factor 6	0.18	0.57
Factor 11	0.13	0.72
Factor 12	0.01	0.11

Note. (a) N = 80. (b) The means were presented in order, from highest to lowest. (c) A repeated measures ANOVA on the above means revealed a significant effect, F (14, 1106) = 50.81, $p < .01$.

6.8 Children's Engagement with Digital Technologies and Their Demographic Background

This section highlights the relationships between children' engagement and enjoyment in with digital technology and their demographic background: (a) children's age, gender, and child care centres, (b) children's family background and their parents' attitudes, and (c) other factors in child care centres.

The following section firstly starts with the nine areas in children's engagement scale: concentration, energy, complexity and creativity, facial expression and posture, persistence, precision, reaction time, verbal utterances and language, and satisfaction. The general ranking score was then reported with comparison with children's demographic background.

6.8.1 Children's Gender and Their Engagement with Digital Technologies

Children's gender was significantly related to their verbal utterances and language in their play (using One-way ANOVA testing), and there were no differences in other engagement areas. Boys were found to more likely use verbal utterances and language when playing than girls, F (1, 78) = 7.92, $p < 0.01$ (see Table 6.9).

Table 6.9

Children's Gender Differences in Their Verbal Utterances and Language in Play

	Mean	*SD*	*n*
Boys Verbal utterances and Language in play	1.96	0.70	44
Girls Verbal utterances and Language in play	1.57	0.49	36

Note. (a) Means expressed via a 3-point scale. *(b)* F (1,78) = 7.92, $p < 0.01$.

6.8.2 Children's Age Groups and Their Engagement in Playing

The 80 children were classified into two groups: 3-year olds and 4-year olds. Children's age was significantly related to their precision and reaction time in their play (using One-way ANOVA testing), and there were no differences in other engagement areas. The 4-year old children were more likely to be rated higher in the precision and reaction time when playing than the 3-year old children (see Table 6.10). This indicates that within the two age ranges children are engaged at similar levels, except within the two areas associated with fine motor

control. This result highlights that despite potential frustrations younger children may encounter with gestural interfaces, they are still fully engaged during play. As identified in Section 6.8, there is a significant relationship between age and fine motor control within the early years. Children go through rapid developmental changes during the early years, particularly in their fine motor development. Within early childhood education, there is a need for continued growth and development in key growth domains, such as fine motor skill development. Therefore iPads appears beneficial in providing children with the opportunity to practice and enhance fine motor skills

Table 6.10

A Comparison between Children's Age and Their Engagement (Precision and Reaction Time) in Play

	Means of Children's age groups		F (1, 78)	p
	3-year old n = 35	4-year old n = 44		
Precision	2.02	2.67	25.67	< 0.01
Reaction time	2.23	2.71	17.12	< 0.01

Note. Means expressed via a 3-point scale.

Children's age was significantly related to their general ranking in their play (using One-way ANOVA testing), F (1, 79) = 8.13, p < 0.01. The lower developmental capacities of younger children influence their ability to be engaged at the same level as older children (Berk, 2013). This does not however imply that young children are not engaged; rather that engagement improves with age.

6.8.3 Children's Parents' Background and Children's Engagement in Playing

There were no significant differences among children's parents' age, gender and highest qualifications and children's engagement with digital technology. There were no siblings within the 80 children, consequently each of the 80 parents were different. A correlation analysis was undertaken between children's nine areas in engagement scale and parents' skills of using technology (PST). It was found that PST was positively related with the children's engagement with digital technology. In Table 6.11, correlations between PST and ratings of concentration, energy, complexity and creativity, facial expression and posture, persistence, precision, reaction time, verbal utterances and language, and satisfaction was

significant. This result highlights that parental confidence with technology plays a role in children's engagement with digital technology. This could be explained in many ways; potentially parents who are more confident with digital technology use it more regularly, thus children have role models who actively engage with digital technology. Parents who are technologically savvy may teach children technical skills, which in turn promote children's engagement with digital technology.

Table 6.11

Correlations between PST and Concentration, Energy, Complexity and Creativity, Facial Expression and Posture, Persistence, Precision, Reaction time, Verbal Utterances and Language, Satisfaction and General ranking

Item	*r*	*p*
Facial expression and Posture	0.22	0.05
Persistence	0.24	0.03
Concentration	0.25	0.03
Reaction time	0.28	0.01
Precision	0.28	0.01
Satisfaction	0.35	< 0.01
Energy	0.18	*ns*
Complexity and Creativity	0.22	0.05
Verbal utterances and Language	0.12	*ns*
General ranking	0.37	< 0.01

Note. N = 80.

6.8.4 Children's Family Background and Children's Engagement in Playing

There were no significant differences between children' engagement in playing and both (a) children's family annual income and (b) number of children in families, $p = ns$. Whilst in Chapter 4 the results highlighted that children from higher income families had a greater exposure to modern gestural interface devices such as smart phones and iPads, this did not translate into significantly higher levels of engagement for children within their play in child care settings.

6.8.4.1 Children's access to different media devices at home and children's engagement in play

One-way ANOVA was used to compare the children's access to different digital technologies at home and children's engagement within play in the child care setting. Access to a computer (laptop or desktop) was significantly related with the areas complexity and creativity, facial expression and posture, persistence and reaction time (see Table 6.12). Children who had access to a computer (laptop or desktop) at home were rated higher in the areas of complexity and creativity, facial expression and posture, persistence and reaction time in the engagement scale. Therefore, prior experience with technological tools, in this case standard computers, promoted children's higher engagement with iPads within multiple areas. Thus, prior access to digital technologies within the home setting can impact children's engagement with digital technologies within educational settings.

Table 6.12

Relationship between Areas of Children's Engagement (Complexity and Creativity, Facial Expression and Posture, Persistence and Reaction Time) in Play and Access to Computer (Laptop or Desktop)

	Access to computer (laptop or desktop)		*F (1,78)*	*p*
	Yes *n* = 64	No *n* = 16		
Complexity and Creativity	2.10	1.83	7.02	0.01
Facial expression and Posture	2.94	2.72	3.99	0.05
Persistence	2.89	2.61	4.84	0.03
Reaction time	2.57	2.24	4.39	0.04

Note. Means expressed via a 3-point scale.

It was found that access to video games (e.g. Xbox, Playstation, or Wii) was significantly related with the area persistence (see Table 6.13). Children who had access to video games at home were rated lower in the area of persistence in the engagement scale. Console systems such as Xbox, Playstation or Wii are tools associated with general gaming (see Chapter 2) rather than specific educational gaming. This result could demonstrate that children who have access to these devices find educational Apps less engaging and therefore their level of persistence within these games is less than children with no access to consoles.

Table 6.13

Children's Engagement (Precision) in Play and Access to Video Games (e.g. Xbox, Playstation, or Wii)

	Access to video games (e.g. Xbox, Playstation, or Wii)		*F (1,78)*	*p*
	Yes *n* = 37	No *n* = 43		
Persistence	2.73	2.93	4.03	0.05

Note. Means expressed via a 3-point scale.

It was found that access to iPads or similar tablet device was significantly related with the areas precision, reaction time, and satisfaction and general ranking (see Table 6.14). Children who had access to iPads or similar tablet device at home were rated higher in the areas of precision, reaction time, and satisfaction and general ranking in the engagement scale. This result indicates that when children have prior experience with iPads or similar devices, this prior experience relates significantly to areas within their engagement. As children have access to these devices within the home and are likely observing their parents role-modelling use, it would be expected that an engagement area such as precision and reaction time would improve, as the children get more comfortable with the technology. The general ranking and satisfaction was also significantly related to home iPad access, which may indicate that parents are aware of their children's heightened interest and engagement with such technologies and therefore purchased them for child use.

Table 6.14

Children's Engagement (Precision) in Play and Access to iPad or Similar Tablet Device

	Access to iPad or similar tablet device		*F (1,78)*	*p*
	Yes *n* = 23	No *n* = 57		
Precision	2.64	2.28	5.53	0.02
Reaction time	2.79	2.39	8.99	< 0.01
Satisfaction	2.53	2.15	10.14	< 0.01
General ranking	4.16	3.53	9.54	< 0.01

Note. Means expressed via a 3-point scale in precision, reaction time, and satisfaction, and means express via a 5-point scale in general ranking.

Internet access was significantly related with the areas complexity and creativity, and persistence (see Table 6.15). Children who had access to Internet at home were rated higher in the areas of precision, reaction time, and satisfaction and general ranking in the engagement scale. Again, these results highlight that children's prior exposure to digital technology, such as access to the Internet allows them to have higher levels of engagement when using those or other digital technologies within learning environments. This highlights that children who come to educational settings with limited exposure to digital technology will find the process of assimilation more difficult.

Table 6.15

Children's Engagement (Precision) in Playing and Access to Internet

	Access to Internet		*F (1,78)*	*p*
	Yes *n* = 62	No *n* = 18		
Complexity and Creativity	2.09	1.88	4.86	0.03
Persistence	2.90	2.62	5.36	0.02

Note. Means expressed via a 3-point scale.

6.8.4.2 Frequencies of children' access to different media devices at home and children's engagement in playing

It was found that frequencies of children's access to computer (laptop or desktop) were significantly related with the areas precision and reaction time and general ranking (see Table 6.16). Children who had more frequent access to computer (laptop or desktop) at home were rated higher in the areas of precision and reaction time in the engagement scale and in the general ranking in playing. Whilst the previous few results have focused on access to digital technologies, this result highlights that children who use these technologies regularly have higher levels of engagement with finite skills of technology use such as precision and reaction time. Furthermore, the overall ranking is significantly related with children's access to computers to laptops at home, which again highlights that prior use of digital technologies within the home influences children's use within education settings.

Table 6.16

Children's Engagement (Precision and Reaction Time and General Ranking) in Playing and Frequencies of Children's Access to Computer (Laptop or Desktop)

	Access to computer (laptop or desktop)						*F (5, 74)*	*p*
	1 *n* =22	2 *n* =2	3 *n* =12	4 *n* =24	5 *n* =19	6 *n* =1		
Precision	2.07	2.67	2.11	2.60	2.59	3.00	3.03	0.02
Reaction time	2.20	2.67	2.26	2.73	2.68	3.00	3.41	<0.01
General ranking	3.35	3.67	3.40	4.00	3.89	5.00	2.40	0.05

Note. 1 = have never been used, 2 = at least once a year, 3 = at least once every six months, 4 = at least once a month, 5 = at least once a week, and 6 = at last once a day.

Children's frequency of access to a smartphone was significantly related with the area satisfaction (see Table 6.17). Children's level of satisfaction could be related to their prior use of Smartphones, in that they enjoy the experience and therefore when using other devices that utilise a gestural interface (iPad) they find the experience enjoyable and hence satisfying.

Table 6.17

Children's Engagement (Satisfaction) in Playing and Frequencies of Children's Access to Smartphone

	Access to Smartphone						*F (5, 74)*	*p*
	1 *n* =34	2 *n* =7	3 *n* =10	4 *n* =16	5 *n* =10	6 *n* =3		
Satisfaction	2.22	2.10	2.08	2.22	2.73	2.33	2.39	0.05

Note. 1 = have never been used, 2 = at least once a year, 3 = at least once every six months, 4 = at least once a month, 5 = at least once a week, and 6 = at least once a day.

Children's access to the Internet was significantly related with the areas precision and reaction time (see Table 6.18). Children who had access to the Internet at least once a day at home rated highest in the areas of precision and reaction time in the engagement scale. This result highlights again that prior experience within children's home settings influence children engagement with digital technology experiences within finite skills of using technology, such as precision and reaction time.

Table 6.18

Children's Engagement (Precision and Reaction Time) in Playing and Frequencies of Children's Access to Internet

	Access to Internet						*F (5, 74)*	*p*
	1 *n* =34	2 *n* =7	3 *n* =10	4 *n* =16	5 *n* =10	6 *n* =3		
Precision	2.13	2.37	2.35	2.73	2.42	3.00	2.57	0.03
Reaction time	2.25	2.73	2.43	2.81	2.54	3.00	3.18	0.01

Note. 1 = have never been used, 2 = at least once a year, 3 = at least once every six months, 4 = at least once a month, 5 = at least once a week, and 6 = at least once a day.

6.8.5 Parents' Attitudes towards iPads or Tablet Devices Designed for Preschool Educational Purposes and Children's Engagement in Playing

Parents' attitudes towards the use of iPads or tablet devices were significantly related to children's playing in concentration, complexity and creativity, facial expression and posture, persistence, precision, reaction time, satisfaction and general ranking in engagement scale (Table 6.19). Parents who rated themselves as "strongly agree" in relation to iPads or tablet devices being used for preschool educational purposes had children who were involved most in the above areas. This result is the clearest indication that parental attitudes play a large role in children's engagement with digital technology. It could be that parents model positive attitudes towards digital tools; hence their children are more engaged.

Table 6.19

Parents' Attitudes towards the Use of iPad or Tablet Devices and Children's Playing in Concentration, Complexity and Creativity, Facial Expression and Posture, Persistence, Precision, Reaction Time, Satisfaction and General Ranking in Engagement Scale

	Parents' attitudes towards the use of iPad or tablet devices					*F (4, 75)*	*p*
	1 *n* =5	2 *n* =10	3 *n* =16	4 *n* =34	5 *n* =15		
• Concentration	2.00	2.98	2.84	2.75	2.99	5.96	< 0.01
• Complexity and Creativity	1.47	2.20	2.03	2.03	2.19	4.81	< 0.01
• Facial expression and Posture	2.27	3.00	2.96	2.89	2.99	3.92	<0.01
• Persistence	2.27	3.00	2.82	2.81	2.97	2.84	0.03
• Precision	1.43	2.40	2.32	2.42	2.68	4.12	<0.01
• Reaction time	1.77	2.50	2.42	2.50	2.84	4.04	<0.01
• Satisfaction	1.57	2.28	2.23	2.25	2.52	3.79	<0.01
• General ranking	2.40	3.82	3.51	3.75	4.21	5.29	<0.01

Note. 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree.

6.8.6 Other factors that Influence Children's Digital Technology Use and Engagement

This section reports the significant relationships between the other 15 factors from Section 6.7 and children's engagement with digital technology.

6.8.6.1 Factor 1 (use of trial and error)

Factor 1 (Use of Trial and Error) was significantly correlated with the following areas in children's engagement scale (See Table 6.20). Interestingly, children's use of trial and error practices within gameplay led to negative correlation within overall engagement. Therefore, the more often children used this strategy to solve numeracy equations, the less engaged they were with the process.

Table 6.20

Correlations between Factor 1 and Facial Expression and Posture, Precision, Reaction Time, and General Ranking

Item	*r*	*p*
Facial expression and Posture	0.31	< 0.01
Reaction time	-0.25	0.03
Precision	-0.33	< 0.01
General ranking	-0.28	0.01

Note. N = 80.

6.8.6.2 Factor 2 (used elements of gestural interfaces)

Factor 2 (Used Elements of Gestural Interfaces) was significantly correlated with the following areas in children's engagement scale (See Table 6.21). Contrary to children's use of trial and error in Section 6.8.6.1, this result explains that when children use the gestural interface features they had higher levels of engagement in almost each area. This result clearly shows that educators and parents should encourage children to use the gestural interface device to maintain engagement within gameplay. This will require adults to scaffold children's use of the interface to maximise the Apps' potential.

Table 6.21

Correlations between Factor 2 and Persistence, Concentration, Precision, Reaction Time, Satisfaction, Energy, Complexity and Creativity, Verbal Utterances and Language, and General Ranking

Item	*r*	*p*
Persistence	0.25	0.02
Concentration	0.26	0.02
Reaction time	0.59	<0.01
Precision	0.66	<0.01
Satisfaction	0.35	<0.01
Energy	0.23	0.04
Complexity and Creativity	0.39	<0.01
Verbal utterances and Language	0.26	0.02
General ranking	0.65	<0.01

Note. N = 80.

6.8.6.3 Factor 3 (other children initiate involvement in play)

Factor 3 (other children initiate involvement in play) was significantly correlated with the following areas in children's engagement scale (See Table 6.22). This result highlights the potential for digital technology to be a socially engaging experience. When another child interacted with a child playing with the iPad, the child's level of engagement went up in seven areas as well as their overall ranking. Therefore, children's social interaction with digital technology can lead to higher levels of engagement for the child.

Table 6.22

Correlations between Factor 3 and Persistence, Precision, Reaction Time, Satisfaction, Energy, Facial Expression and Posture, Verbal Utterances and Language, and General Ranking

Item	*r*	*p*
Persistence	0.25	0.02
Facial expression and Posture	0.26	0.02
Reaction time	0.39	<0.01
Precision	0.23	0.05
Satisfaction	0.52	<0.01
Energy	0.57	<0.01
Verbal utterances and Language	0.37	<0.01
General ranking	0.46	<0.01

Note. N = 80.

6.8.6.4 Factor 5 (the player involves other children in play)

Factor 5 (The player involves other children in play) was significantly correlated with the following areas in children's engagement scale (See Table 6.23). As with Section 6.8.6.3, this result emphasises that digital technology can be more engaging when children participate in social interactions during play.

Table 6.23

Correlations between Factor 5 and Precision, Reaction Time, Satisfaction, Energy, Verbal Utterances and Language, and General Ranking

Item	*r*	*p*
Reaction time	0.35	<0.01
Precision	0.27	0.01
Satisfaction	0.39	<0.01
Energy	0.60	<0.01
Verbal utterances and Language	0.52	<0.01
General ranking	0.40	<0.01

Note. N = 80.

6.8.6.5 Factor 8 (the player stops other children's interruption)

Factor 8 (The player stops other children's interruption) was significantly correlated with the following areas in children's engagement scale (See Table 6.24). Whilst the previous two results highlighted children's increased engagement during play with social interaction, this result demonstrates that when children want to play with the iPad and cease others' interruption, their engagement levels also improve. Factors such as reaction time and precision were significantly related to stopping interruptions, which indicates that children were trying to concentrate when stopping others' interruptions.

Table 6.24

Correlations between Factor 8 and Precision, Reaction Time, Satisfaction and General Ranking

Item	*r*	*p*
Reaction time	0.34	<0.01
Precision	0.33	<0.01
Satisfaction	0.39	<0.01
General ranking	0.40	<0.01

Note. N = 80.

6.8.6.6 Factor 13 (struggled using fine motor skills in GI)

Factor 13 (struggled using fine motor skills in GI) was significantly correlated with the following areas in children's engagement scale (See Table 6.25). Students who struggled with

fine motor skills in GI play had lower ratings in precision, reaction and general ranking in the engagement scale. This result is a clear indication that children's fine motor skills help determine their level of engagement within play. As highlighted in Section 6.8.2, children's age had a significant relationship with their engagement levels. This result highlights that younger children with less refined fine motor skills have lower engagement using iPads.

Table 6.25

Correlations between Factor 13 and Precision, Reaction Time and General Ranking

Item	*r*	*p*
Precision	-0.67	<0.01
Reaction time	-0.58	<0.01
General ranking	-0.53	<0.01

Note. N = 80.

6.8.6.7 Factor 14 (the player seeks hardware support during play)

Factor 14 (the player seeks hardware support during play) was significantly correlated with the following areas in children's engagement scale (See Table 6.26). Children who sought hardware support during playing had lower ratings in precision, reaction and general ranking in the engagement scale. It can be assumed that children who did not know how to operate the hardware features of the iPad had limited experience with the devices and this impacted their level of engagement. Therefore, children's prior experience in using these devices allows them within educational settings to focus on their learning rather than the operational components of using digital technologies. Hence prior experience using these tools before they get to a school setting would benefit users' learning.

Table 6.26

Correlations between Factor 13 and Precision, Reaction Time and General Ranking

Item	*r*	*p*
Precision	-0.37	<0.01
Reaction time	-0.31	<0.01
General ranking	-0.22	0.05

Note. N = 80.

6.9 Children's Numeracy Improvement Compared with Their Characteristic Factors and Playing Activities in Observation

This section firstly created new variables based upon children's numeracy results in pre- and post-tests, then the new variables were analysed by using Correlation and One-way ANOVA to compare with children's characteristic factors.

6.9.1 Variables Numeracy1, Numeracy2, Numeracy3, Numeracy4 and Numeracy5

Children's numeracy abilities were tested in the five areas of: (a) numeral identification, (b) counting, (c) arithmetic problems, (d) shape identification, and (e) patterns based on Ramani and Siegler's (2011) and Segal's (2011) studies. Table 6.3 shows that children's numeracy abilities were significantly different between pre-test results and post-test results in all the five areas. In this section, the children's numeracy results will be compared by using the post-test results minus pre-test results in all the five areas of numeracy abilities. Therefore, the following new variables were created: numeracy1 was created by using post-test results of the area numeral identification minus pre-test results; numeracy2 was created by using post-test results of the area counting minus pre-test results; numeracy3 was created by using post-test results of the area arithmetic problems minus pre-test results; numeracy4 was created by using post-test results of the area shape identification minus pre-test results; and numeracy5 was created by using post-test results of the area patterns minus pre-test results. Table 6.27 shows the means and standard deviations of the new five variables.

Table 6.27

Means and Standard Deviation of Numeracy1, Numeracy2, Numeracy3, Numeracy4 and Numeracy5

	Mean	*SD*	*N*
Numeracy1 - numeral identification	0.52	0.91	80
Numeracy2 – counting	1.56	2.52	80
Numeracy3 - arithmetic problems	0.39	0.68	80
Numeracy4 - shape identification	0.51	0.81	80
Numeracy5 – patterns	0.70	0.68	80

Table 6.27 and Section 6.3 show that the children's numeracy abilities improved in all the five areas. Consistent with Section 6.4, this highlights that every area within the numeracy measure improved post playing Apps via the iPad.

A One-Way ANOVA was conducted between the participants' age and their numeracy improvement. It was found 3 year old children' numeracy was improved more significantly in the areas of arithmetic problems than the 4 year olds (See Table 6.28).

Table 6.28

A Comparison between Children's Age and the Means of Their Numeracy Improvement in Numeracy1, Numeracy2, Numeracy3, Numeracy4 and Numeracy5

	Means of Children's age groups		F (1, 78)	p
	3-year old n = 36	4-year old n = 44		
Numeracy1 – numeral identification	0.53	0.50	0.02	0.89
Numeracy2 - counting	1.69	1.45	0.18	0.68
Numeracy3 - arithmetic problems	0.58	0.23	5.68	0.02
Numeracy4 - shape identification	0.47	0.55	0.16	0.69
Numeracy5 - patterns	0.69	0.70	0.00	0.95

A One-Way ANOVA was conducted between the participants' age and their numeracy improvement. It was found that 3 year old children' numeracy was improved more significantly in the areas of arithmetic problems than the 4 year olds (See Table 6.29).

Table 6.29

A comparison between Each Child Care Centre and the Means of Their Children's Numeracy Improvement in Numeracy1, Numeracy2, Numeracy3, Numeracy4 and Numeracy5

	Child Care Centres			F (1, 78)	p
	Centre A n = 20	Centre B n = 20	Centre C n = 40		
Numeracy1 – numeral identification	0.70	0.85	0.25	0.02	0.89
Numeracy2 – counting	1.55	2.15	1.28	0.18	0.68
Numeracy3 - arithmetic problems	0.60	0.30	0.33	5.68	0.02
Numeracy4 - shape identification	0.70	0.95	0.20	0.16	0.69
Numeracy5 – patterns	0.65	0.85	0.65	0.00	0.95

6.9.2 Variables Numeracy1, Numeracy2, Numeracy3, Numeracy4 and Numeracy5 and Children's Characteristics

This section compares the five new variables with the children's age. Correlation was used and it was found that Numeracy2 was significantly correlated with children's age, r = -0.33, p < 0.01; and numeracy3 was significantly correlated with children's age, r = -0.36, p < 0.01. These findings show that younger children's counting abilities and arithmetic problem solving abilities improved more after playing iPads than the older children. This finding is a very interesting given that children's levels of engagement increased with age (see Section 6.8.2). However, it does indicate that young children, despite fine motor control issues (see Section 6.7), had higher levels of learning in counting and arithmetic problem solving than older children. Hence gestural interface devices and associated Apps appear appropriate for 3 and 4 year old children's learning.

Children's access to an iPad and frequencies of using an iPad at home have also been compared with variables numeracy1, numeracy2, numeracy3, numeracy4, and numeracy5. One-Way ANOVA was used, and it was found that there was no significant relationship between children's numeracy improvements and access to iPads and frequency of use at home, p = *ns*. Therefore, whilst prior exposure to iPads impacted children's level of engagement (see Table 6.14) there was no significant relationship to their numeracy learning outcomes.

6.9.3 Variables Numeracy1, Numeracy2, Numeracy3, Numeracy4 and Numeracy5 and Children's Play and Engagement in Observation

This section compares the new five variables numeracy1, numeracy2, numeracy3, numeracy4 and numeracy5 with children's playing rating in observations. It was found that children's numeracy improvement was not significantly correlated with children's general ranking within the engagement scale in observations, $p = ns$. This finding suggests that even when children had high levels of engagement during play, this engagement did not improve children's numeracy learning outcomes.

The 15 factors in children's engagement in playing an iPad were also used to compare with the new five variables numeracy1, numeracy2, numeracy3, numeracy4 and numeracy5. Correlations were used and Table 6.30 shows that the factor 1 (uses trial and error) was significantly correlated with numeracy2 and numeracy3; factor 2 (used elements of GI) was significantly correlated with numeracy3; factor 7 (the player ignores other children's engagement) was significantly correlated with numeracy1 and numeracy4; factor 10 (The player seeks software support during playing) was significantly correlated with numeracy3; factor 14 (The player seeks hardware support during playing) was significantly correlated with numeracy3; and factor 15 (the player seeks numeracy support during playing) was significantly correlated with numeracy3 and numeracy5.

Table 6.30

Correlation of 15 Other Factors and New Variable Numeracy1, Numeracy2, Numeracy3, Numeracy4 and Numeracy5

	Numeracy1	Numeracy2	Numeracy3	Numeracy4	Numeracy5
Factor 1: Use of Trial and Error	0.02	-0.26*	0.24*	0.20	-0.10
Factor 2: Used Elements of Gestural Interfaces	-0.02	0.18	-0.31**	-0.14	0.15
Factor 3: Other children initiate involving in playing	-0.02	0.11	-0.11	0.18	<0.01
Factor 4: Other children distract playing with other activities	-0.06	-0.14	0.03	-0.04	0.01
Factor 5: The player involves other children in playing	-0.07	-0.02	-0.20	0.06	0.06
Factor 6: The player distracts other children during playing	-0.08	-0.13	-0.01	-0.14	0.04
Factor 7: The player ignores other children's engagement	0.33**	0.11	0.16	0.29**	0.04
Factor 8: The player ceases other children's interruption	-0.05	0.13	-0.11	-0.08	<0.01
Factor 9: The player's own private speech during playing	0.08	-0.08	0.08	-0.01	0.02
Factor 10: The player seeks software support during playing	0.07	0.10	0.30**	0.03	-0.10
Factor 11: The players seeks carer's assistance	-0.08	-0.05	-0.02	-0.07	-0.16
Factor 12: The player terminates the game	-0.06	-0.07	-0.06	-0.07	-0.12
Factor 13: Struggled using fine motor skills in GI	0.01	-0.06	0.20	0.11	-0.06
Factor 14: The player seeks hardware support during playing	-0.02	0.05	0.26*	0.16	-0.07
Factor 15: The player seeks Numeracy support during playing	<0.01	0.03	0.26*	-0.06	-0.26*

Note. * $p < 0.05$, ** $p < 0.01$.

The findings show that the children who used trial and error more in their play declined in their counting skills; however their abilities in arithmetic problems solving improved. Moreover, when the children used elements of gestural interface more in their play, their numeracy abilities in arithmetic problem solving decreased. It is a puzzling result in that one would expect children's appropriate use of the gestural interface to correlate to positive

numeracy outcomes. Interestingly, it was also found that when the children ignored other children's engagement in play, both their numeracy abilities in number identification and shape identification improved. This may suggest that children are not necessarily ignoring others: rather they are concentrating during their play and consequently learning. The findings also show that when the children sought software support and hardware support more during their play, their abilities in arithmetic problem solving improved. Further, it was also shown that children, who sought numeracy support during play, improved their arithmetical problem solving abilities while their shape identification abilities decreased.

6.10 Summary

This chapter provided results from Phase 3: children's play phase. Findings indicated that children enjoyed playing with iPads as they significantly favoured their use after playing with them. One of the most important findings from this study was that the pre- and post-test results from children's numeracy measures showed a significant improvement in all areas of the numeracy measure, confirming educators' and parents' beliefs. Furthermore, results showed that there was a consistently high level of engagement during children's use of digital technology, although verbal utterances and language were low. Although this highlights the social concerns of early childhood educators outlined in Chapter 4, there were many social interactions within children's digital technology use beyond just the spoken word. Additionally, when children were observed interacting socially with others their overall level of engagement increased. The conflicting results regarding children's social engagement with digital technology will be explored in the next chapter.

When the results from the Engagement Scale were compared with the Survey results, two key areas stood out. Firstly, parents confident with their own technology use, as well as approving children's technology use, led to higher levels of engagement for their children. This may be due to the role modelling and support children receive about the role of technology within their lives. Secondly, children's prior experience via access and use of technology also increased their engagement ranking significantly. Therefore, it is pertinent that children have prior access to these tools to maximise engagement within educational settings. This will lessen the potential implication of a digital divide existing between children with access to technology within their homes and children who do not.

The high levels of engagement and significant improvements within numeracy outcomes indicate that the highest rated Apps used in this study are indeed appropriate for use with young children. Additionally, the most popular App played by children when they began their observation period was also the highest-ranking App within GIARS.

Children often used trial and error rather than utilising the gestural interface to solve numeracy problems. Several children struggled with the elements of the gestural interface. This finding was directly related to younger children, which can be understood in terms of their developing fine motor skills.

The next chapter will discuss the results of the study in relation to the questions asked: What is already known and the contribution the current study makes regarding the integration of digital technology into early childhood education; discussion of future research and recommendations.

Chapter VII Discussion

7.1 Introduction

This chapter discusses the main findings of the present study with reference to the research questions. The sections within this chapter are framed within the Digital Play model (Figure 7.1); when digital technologies are integrated appropriately within early childhood, play-based settings they have the potential to be categorised as digital play and fulfil the Digital Play model (see Section 2.7.4). In this study, digital play is defined when there is an assimilation of early childhood contexts, play and digital technologies that merge to influence children's enjoyment and engagement within learning to facilitate curricula outcomes. The component elements of the Digital Play model – early childhood, play-based learning and digital technologies – will be discussed in relation to the research questions and findings to analyse the role of digital technologies in early childhood. This study is timely in the context of increased adoption of digital technologies and provides evidence of philosophical arguments to determine if digital technologies can support their own model of play within the early years.

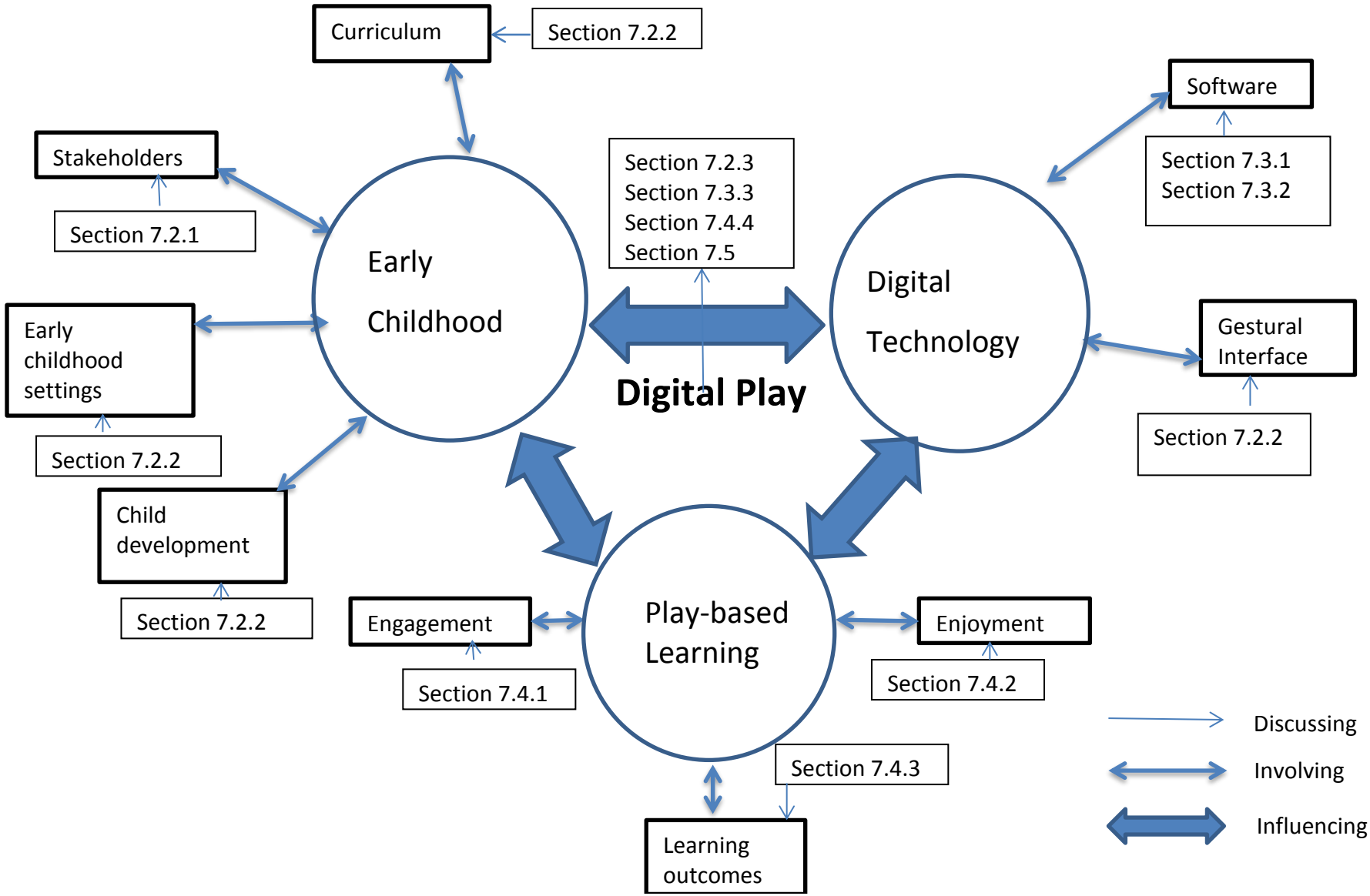

Figure 7.1. Framework of the research and discussion of the findings within Digital Play model.

7.2 Early Childhood

For digital technologies to be considered within the educational model of digital play, an assimilation of digital technologies into early childhood needs to occur (see Figure 7.1). Successful integration of digital technologies into early childhood settings needs acceptance by stakeholders. Therefore, analysis of educators' and parents' current use and opinions towards digital technology within the early years becomes apparent. Section 7.2 addresses Question 1 of the study, which asks: Are digital technologies being used with children aged 3-4 and what are the prevailing attitudes that child care educators and parents have towards the integration of gestural interface technology via digital technology? A number of themes will be discussed including current use of digital technology within home and care, attitudes towards integration and the use of gestural interface devices and associated Apps.

7.2.1 Children's Digital Technology Use within Home and Care

The study showed that children had greater access and frequency of use of digital play devices within the home than in care settings. Educators need to be aware that children do indeed have familiarity and practice with using digital technology within their daily home life. Lee (2015, p.947) explains that digital technologies are a dominant play activity for young children, using such technologies as 'mp3 players, iPods, iPads, game apps and television. Educators must be aware of the types and functions of digital technology in the lives of children they educate; these tools are used by children to make sense of their world and they become part of their problem-solving solutions (Edwards, 2013b). Experienced early childhood educators may have little to no experience working with children who utilise these technologies and consequently may miss opportunities to tap into children's interests and learning pathways (Mercer, 2014; Plowman & McPake, 2013). Therefore, the integration of modern digital technologies, such as gestural interfaces, into educational settings may mirror the learning styles and dispositions that children use within their home environment and consequently bring to educational settings.

Whilst overall access to all forms of technology is more likely in home than care, access to emergent technology was not guaranteed for all children. Household income played a significant role in the children's frequency of access to Smartphones and iPads. The children from high-income families had the most access. This indicates that there is a potential for a

digital divide based upon families' ability to afford new technologies (Blackwell et al., 2013; NAEYC & the Fred Rogers Centre, 2012). Early childhood services have the potential to limit the digital divide by providing digital technology that will prepare children for future educational opportunities. It is important that young children are familiar with new technologies before entering school, where these technologies are prevalent, to prepare them for their educational and working futures (Daugherty et al., 2014). This prior experience allows children to spend less time understanding how to use the technology, so they can focus on the specific learning outcome being taught by the device.

The most commonly accessed and frequently used digital technologies in children's home settings were television and DVDs, consistent with previous findings (Edwards & Henderson, 2013). The educational value of television and DVDs is limited due to the one-way, non-interactional screens that have limited potential to engage children or meet their specific developmental capacities (Blackwell et al., 2014). Whilst this is of concern to researchers and educators, the results from this study give rise to the notion that whilst there are many media reports around the dangers of passive screen watching for children, parents may believe it is not a problem for their own children (Funk et al., 2009; Plowman & McPake, 2013; Takeuchi, 2011). Early childhood services have the opportunity to educate parents about the developmental implications of passive screen watching and promote interactive screens within service delivery, thereby informing parents of screen choice options for their children. With this understanding, early childhood educators can promote the use of educationally appropriate alternatives, such as gestural interfaces.

This study found that the most commonly accessed and used digital technology in child care settings were standard computers. This was not unexpected given that Yurt and Cevher-Kalburan's (2011) study with early childhood educators found that 94.7% thought that computer usage was appropriate for early childhood education. However, standard desktop/laptop computers are not seen as early childhood friendly learning tools due to the difficulties associated with use (fine motor control issues and durability concerns) (Bower, 2012; Kucirkova et al., 2014; Plowman & McPake, 2013). Early childhood settings need to consider integrating gestural interface devices, which are better suited to the developmental

capacities of young children, to accommodate learning opportunities. The integration of such devices into child care settings however still face many challenges.

7.2.2 Integrating Digital Technology into Early Childhood Settings

Both educators and parents believe that digital technologies should be integrated into child care services. That result indicates that early childhood stakeholders are becoming aware of the potential educational advantages for the integration of digital technology into best practice and are willing to advocate for its integration (Bower, 2012; NAEYC & Fred Rogers Centre, 2012). In terms of digital technologies becoming an educational model in the form of digital play, this is an important result. If early childhood stakeholders agree that integration should occur this should make integration far more possible. One of the primary reasons identified by early childhood stakeholders for the integration of digital play was the need for children to be exposed to new technologies to aid in their future educational and working careers. This is consistent with literature that discusses the importance of children becoming digital citizens, thereby preparing them for working futures and integration with technologies that develop their pedagogical preferences for school and later work (NAEYC & Fred Rogers Centre, 2012; Plowman & McPake, 2013). Expanding on the point of children's familiarity with digital technology, a poignant comment from one of the participating educators, a director, reflects the changing nature of the responsibility owed by early childhood institutions towards the integration of digital technologies (Winsor & Blake, 2012) when she stated that she:

> *"would probably say that its only been in very recent times that I've felt that as an educational institution that we have a responsibility to introduce educational media into the curricula responsibility as its here to stay and many chn [children] are already familiar with them" [sic].*

This comment highlights the changing nature of early childhood education, combined with regulatory expectations from ACECQA, NQS and NQF, which has led to educators understanding the role that digital technologies can have in effective service delivery.

Educators believed that digital technology could enhance their teaching practice and enhance children's cognitive development and their numeracy and literacy learning. This view is consistent with some of the reported cognitive benefits of digital technology, including

increased attention span, creativity and problem solving skills, consistency, knowledge expansion and application, persistence, self-confidence and self-esteem within learning, development of metacognitive skills, mathematical skills and concept knowledge (Clements, 2002; Donahoo, 2014; Lee, 2015; Plowman & McPake, 2013; Tootell et al., 2013; Vernadkis et al., 2005). Educators demonstrated a higher understanding than parents of the potential for digital technology to be used holistically in the curricula and how digital technology can support development. Educators' views within this study were consistent with Plowman and McPake (2013), who suggest that children be supported in their holistic development through a process of learning and interdependence, which they believe matches digital technology pedagogy. This indicates that if digital technology is integrated into child care settings, it would be used across a broad range of curricula domains by educators. Consequently, digital technologies will be integrated with purpose in early childhood settings as a specific learning tool; a key however will be if educators have the specific skills to appropriately use digital technology with young children.

The overwhelming majority of both educators and parents thought that gestural interface devices were appropriate for young children. Some of the primary reasons identified were that gestural interface devices are easy for children to use, intuitive within design and aided children's thinking skills. These attitudes are consistent with literature (Bower, 2012, 2013; Lee, 2015; Siegle, 2013; Tootell et al., 2013). In addition, children can independently use emergent digital technologies such as iPads that use gestural interface designs (Bower, 2012). This allows early childhood educators to utilise digital technologies within a play-based learning environment, whereby children are free to come and go, which fosters intrinsically motivated play.

Apps were also considered to be developmentally appropriate for preschool children by both parents and educators. This indicates that both educators and parents trust that Apps developed for gestural interfaces will meet the developmental capacities of the children they claim to plan for. However, Kucirkova et al. (2014) state that Apps have the same historical problems that all software designed for young children have, which is that the contextual variance of children limits usability. Thus it becomes apparent that early childhood educators and parents need to be trained in the ability to identify and appropriately scaffold children's

selection and use of Apps. Within this study, the majority of parents used the classification system (e.g. G, PG, M etc.) to decide if the media was suitable for their child, which can also be found on the Australian website *Australian Council on Children and the Media*. This method is reliable for preventing children from seeing inappropriate violent or sexual images, however it is not necessarily a valid guide for developmental appropriateness. Consequently, if Apps are being selected based on their rating classification, there is a risk that children will be exposed to a variety of Apps that have limited developmental appropriateness or educational value. The use of websites such as *Common Sense Media* would assist educators and parents traversing the multitude of options available within App stores, such as Apples.

Both parents and educators identified a need for training in the effective use of digital technology. Educators' self-reported skills of using technology were significantly lower than the parents. Educators need to have confidence and skills within the use of digital technologies including participation with peers and colleagues within professional development opportunities (Blackwell et al., 2014; Blackwell et al., 2013: Blake et al., 2012; NAEYC & Fred Rogers Centre, 2012). Moreover, educators need to be provided with appropriate training that facilitates their abilities to integrate digital technologies with young children. The ability to link appropriate technologies within digital technology use to curriculum require educators to be proficient and confident within their own technological skills. This can be addressed through appropriate funding and resource allocation.

The primary themes identified by educators as to the limitations of their use of digital technologies focused on funding available to child care centres, cost of digital technology and training opportunities. Invariably the majority of respondents identified that money was the primary obstacle to digital technology integration. This links to both the cost of the technology itself as well as the limited funding available to child care centres in general. This suggests that services may not be able to access appropriate digital technology due to the cost of those devices (Shamir et al., 2009). As discussed by Ntuli and Kyei-Blankson (2012), funding bodies within early childhood have a duty to not only give early childhood services access to quality technological tools, but to also finance appropriate training and development. By providing appropriate funding and training, early childhood services will be able to provide centres with contemporary tools that reflect their learners' digital

environments. This will also assist children in their transition to the school sector as well as up skill early childhood staff to modern teaching pedagogies.

Financial concerns were not the only barriers identified for the integration of digital technology into early childhood settings. There were also attitudinal behaviours. Whilst over half of the parents and educators expressed enthusiasm for the integration of digital technology into child care settings, there was still a proportion who did not. This validates the notion that the field of early childhood is divided about the integration of digital techn (Blackwell et al., 2013; Ficken, 2013). Some early childhood stakeholders showed a preference for more traditional forms of play such as concrete manipulative objects commonly associated with child care – balls, books, sandpits and so forth. This highlights that not all stakeholders are welcoming of the integration of digital technologies into early childhood settings (Blackwell et al., 2013), potentially leading to a workforce divided on the implementation of digital technologies and subsequently inappropriate or non-use of digital technologies. This divide is likely to impact on a unified understanding of an educational model such as digital play. There is an undercurrent that digital technologies, particularly modern technological products, are drastically altering the landscape of early childhood to its detriment (Plowman, McPake & Stephen, 2010). There are fears that traditional forms of play will be lost with the advent of the digital technologies, and with a workforce that has little experience or training with how to use digital technologies appropriately, early childhood education will suffer. There seem to be disconnects in what early childhood stakeholders believe to be educational, and development concerns of digital technologies. Bower (2013) and Donahoo (2014) point out that early childhood stakeholders should be concerned with the negative implications suggested by media reports in relation to digital technology. However, this thesis argues that educators should research the benefits and limitations of children's engagement with digital technology to inform their practice and they can also use this as an opportunity to discuss appropriate screen use with parents. This can only be achieved through appropriate in and pre service training.

A concern identified by early childhood stakeholders was the potential for digital technology to negatively affect children's social development. This view is consistent with literature which states that digital technology is feared to be addictive and socially isolating and

detrimental to the development of social and emotional skills (Brown et al., 2012; Finegan & Austin, 2002; McCarrick & Li, 2007; Plowman & McPake, 2013; Plowman & Stephen, 2003; Struppert et al, 2010; Yelland, 2011). Despite these views, this study found that children were constantly engaged with others during their play with iPads, which supports research that demonstrates social benefits associated with the use of iPads within the play-based setting, in particular generating conversation between both children and adults during tablet use (Yelland et al., 2014). Educators can draw on such research and explain the potential social benefits of children's engagement with digital technology to early childhood stakeholders who show concerns in this area.

7.3 Technology

A component element of the Digital Play model (see Figure 7.1) is the digital technologies themselves, in that to be considered able to support digital play, digital technologies must be appropriate for the children within the early years. Consequently, it is pertinent to review if emergent digital technologies such as those utilising gestural interfaces, such as iPads and associated Apps, meet the development and learning needs of young children. The second research question in the study explored the primary roles of the most popular Apps designed for preschool aged children's numeracy learning and whether their design was developmentally appropriate for children. The findings from scores in the Gestural Interface rating Scale (GIARS) will be discussed in relation to the literature and the potential impact on practice, followed by discussing the findings from the Math App Appraisal Scale (MAAS). Some particular factors which impacted the scores in GIARS and MAAS will be also discussed.

7.3.1 Are Apps Developmental Appropriate for Children?

Apps designed for preschool aged age children are very popular (Kucirkova et al. 2014), of the 75,000 Apps on the Apple website (Apple, 2015), 72% target preschool or elementary aged children. In the review of 50 Math Apps, less than half of the most popular Apps targeting preschool children's numeracy development were found to be developmentally appropriate for children aged 3-4 years. Given that early childhood stakeholders thought that Apps were indeed developmentally appropriate, it raises questions about early childhood stakeholders' awareness of the divergent qualities of Apps available to them. If early

childhood stakeholders are not adequately educated to identify developmentally appropriate Apps, they may be exposing children to inappropriate games, which will have an impact on the quality of digital technology within the early childhood sector. Research shows that when children engage with well-designed games, learning and cognitive skills can be enhanced (Lieberman et al., 2009). Moreover, well-designed games can promote high social interaction and healthy behaviours (Lieberman et al., 2009). However, poorly designed games can impact children negatively, or even harm their development in extreme circumstances. Such harms include aggressive or anti-social behaviour, fear and anxiety, poor health habits and teaching other unwanted lessons (Lieberman et al., 2009). Therefore, understanding how to identify quality educational Apps and understand game design processes becomes imperative for early childhood stakeholders (Mercer, 2014). It is also pertinent that parents and educators are able to determine the developmental appropriateness of digital technologies for the specific context of the children they care for and educate.

Many Apps were not developmentally appropriate, indicating that designers have a limited understanding of young children and their developmental capacities or focus on the commercial possibilities of Apps over developmental concerns. This will limit the impact of digital technology to make new concepts and tasks meaningful, relevant, and respectful of children. In particular, the finding about low scores in scaffolding and process orientation is consistent with Falloon's (2013) statement that effective App design should provide communication in ways young children can access and understand, including accessible and understandable instructions and teaching elements, as well as incorporating formative and corrective feedback. This relates to the contextual nature of gameplay, which is one of the biggest concerns about the relevance of digital technology in early childhood. Children may not be getting the specific contextualised feedback they require from Apps and get lost when engaging in complicated software not specifically tailored to their needs or learning styles (Plowman et al., 2010; Struppert et al., 2010). Creators of educational Apps for children cannot know individual children's interests, strengths and needs, however they can make Apps that are developmentally appropriate and base these on developmental norms and effective early childhood pedagogies (Varol & Colburn, 2007). In addition, educators and parents need to be aware how Apps link to the outcomes they are trying to teach and ensure Apps provide appropriate support for learners, or conversely provide that support for

children. It is imperative that educators interact with children during their play with Apps in the same way they would a board game, puzzle or other task they believed needing scaffolding and support. In this way they will be able to maximise the effectiveness of the App by supporting the child through specific contextualised feedback regarding their learning.

The finding that feedback or 'structure other than verbal formats' were only seen in developmentally appropriate Apps stimulates discussion about appropriate pedagogies utilised within digital technology. Although there is some disagreement about whether digital technology does or does not support children's learning within traditionally based play-based curriculums (Struppert et al., 2010; Yelland, 2011), the main difference arises from educators' beliefs about play and how children's use of digital technologies fits within educators systematic belief of play (Edwards, 2013a). Traditionally within play, adults or peers in children's learning provided feedback for specific contextual information, which Sim et al. (2006) points out is a major limitation of feedback provided in digital play applications. However, findings emphasised the importance of feedback other than verbal formats, which allows students to develop skills of problem-solving and learning by doing. This actually mirrors other forms of play within early childhood settings including sensorimotor or practice play, make-believe play, and games with rules (NAEYC & Fred Rogers Centre, 2012). Furthermore, early childhood stakeholders should be aware of the feedback and instructions given by Apps to assist in understanding the function the App may play within a play-based environment whereby children need to interpret and make meaning of content. This will allow them to fit digital technology more seamlessly into their play-based settings.

The finding about the low scores in spatial design and the anatomy of a gesture shows that there is limited recognition of children's developing fine motor skills by App designers. Whilst young children are able to use gestural interfaces much more easily than traditional computer mouse and keyboard designs, there are still limitations due to emerging fine motor control. That the youngest children in the study struggled with elements of the interface highlights that when choosing developmentally appropriate Apps for young children, it is important to consider not only academic content but also children's ability to use the interface features.

It was found that developmentally appropriate Apps used better gestural interface features than non-developmentally appropriate Apps. This means that developmentally appropriate Apps constitute better use of digital technology via gestural interface devices. Literature on embodiment suggests that sensorimotor experience in children's cognitive processes (Rubichi et al., 2011) (such as children's use of developmentally appropriate Apps), allows bodily rooted knowledge to influence the perception process that affect children's cognitive development (Barsalou, 2008; Segal, 2011; Wilson & Golonka, 2013). This is owing to gestural interfaces being interactive screens, which respond to children's movements and interactions and can be scaffolded to promote development and learning, which should not be put in the same category as non-interactive screens (NAEYC & Fred Rogers Centre, 2012). Whilst the interactive designs of gestural interface devices are certainly appropriate for young children, the development of age-appropriate software needs to go hand-in-hand with the intuitive design of the interface. This highlights to the early childhood sector that gestural interface tools are developmentally appropriate for young children's learning and sit within children's need to touch and interact with their learning, thereby providing a level of justification for use.

Developmentally appropriate Apps involved more factors relating to children's cognitive development than non-developmentally appropriate Apps. There has been debate about the benefits of digital technology for children's cognitive development (Plowman et al., 2010; Struppert et al., 2010), in that educators are concerned that it is too abstract and difficult to use digital technology to aid young children's cognition. The main concern from those resistant to the use of digital technology is that when young children engage with digital technologies the learning objectives may get lost as the tools cannot tailor specifically to their children's needs or learning styles (Kucirkova et al., 2014; Plowman et al., 2010; Struppert et al., 2010). However, proponents of digital technology, such as Ellis and Blashki (2004) and Haugland (2000), believe that children over 3 years of age are developmentally ready to explore technology. In addition, there has been an altering in the stance that screen media should be banned for children under 2 after Dr Dimitri Christakis, one of the authors reaffirming the AAP's position on screen time for children stated: 'I believe that judicious use of interactive media is acceptable for children younger than the age of two' (Donahoo, 2014, p. 21). In the present study, developmentally appropriate Apps were found to support

children's numeracy learning (see Section 7.4.3), therefore supporting the notion that children's cognitive development can be enhanced through digital technology and use of developmentally appropriate Apps. Furthermore, some of the reported cognitive benefits identified in other studies include increased attention span, creativity and problem solving skills, consistency, knowledge expansion and application, persistence, self-confidence and self-esteem within learning, development of metacognitive skills, mathematical skills and concept knowledge (Clements, 2002; Donahoo, 2014; Lee, 2015; Plowman & McPake, 2013; Tootell et al., 2013; Vernadkis et al., 2005). Again, these findings support the notion that digital technology can support children's learning and therefore be promoted as a tool for use within early childhood settings.

In the present study, "cost" was significantly related with the quality design of the Apps. Within the Apple store there are large ranges of free and purchased Apps (Apple Inc., 2015). Of the top 50 Apps selected for review in this study 31 were free and 9 were under $1.00. Bower (2013) warns that free Apps are often full of advertising or promotions and try to gain information from the user to manipulate purchases at a later date, and are not appropriate for young children. However, Falloon (2013) indicated that price was not always an obstacle to meeting the features required of effective and engaging Apps, with many paid Apps not being considered developmentally appropriate. Other than Falloon and Bower, there is little discussion about the factor of cost in terms of developmental appropriateness; rather cost is linked to availability and exposure of technology for children (NAEYC & Fred Rogers Centre, 2012; Sim, et al, 2006). The reasons could be that in comparison to laptops and computer-based games, mobile Apps are considered low-cost (sometimes free) in relation to other forms of software. However, the present study investigated the differences between free and paid Apps, and some significant differences were found in relation to the quality of the Apps between free and even low-cost Apps. Well-designed Apps cost money to purchase, and parents and educators should consider the factor of cost when considering using good quality and well-designed Apps.

Lastly, within this section on developmentally appropriate Apps, the particular factor about distracting activities and advertisement involvement was noted in the not-developmentally appropriate Apps. As discussed above, many free Apps are full of advertising or promotions

(Bower, 2013). These can distract young children's learning and are not appropriate for young children. There is little existing research on this factor; however, this is a very common issue for parents, educators and young children using digital technology. Although it is understandable for software (App) development companies to include some advertisement in their Apps for users to consider purchase, the use of advertisements in young children's learning Apps is not appropriate. The use of advertisements may not only seduce young children to click on the purchase button and cost their parents/caregivers money, but may also distract their learning, as the advertisement normally pops out in the middle of play without any warning. Therefore early childhood stakeholders should investigate Apps themselves to ensure there are no advertisements that could impact their children's engagement or seduce children to make costly purchases.

7.3.2 The Primary Roles of Apps

Siegle (2013) classifies any App into six categories: productivity, subject-specific productivity, information-gathering, game, drill and practice and social media apps. Handal et al. (2014) developed MAAS to appraise the role of mobile numeracy Apps based upon the framework of TPACK through three areas: explorative, productivity, and instructive. In the present study, it was found most of the Apps' primary roles were instructive, then explorative and finally productivity based upon their ratings in MAAS. To use the categories developed by Siegle (2013), instructive Apps in MAAS refer to the similar category of drill and practice Apps. The Apps reviewed in this study found that drill and practice was the primary focus, consistent with Attard and Northcote (2011) and Highfield and Goodwin (2013). Varol and Colburn (2007) explain that there is a need for young children to practice and replicate numeracy skills via drill and practice programs. Drill and practices Apps are very repetitive skill-based and tend to reflect structured work style activities rather than fitting within a play-based style of learning (Lim, 2010; Yelland, 2011). Blake et al., (2012) appraise that drill and practice styled Apps primarily lead to certain rote skills but may not be as effective in improving children's conceptual understanding of numeracy ideas. Explorative Apps however, can support children research and investigate their interests, making a significant difference in children's development. The findings in the current study found that the cognitive involvement and Apps' general pedagogical issues were rated only between "to some extent" to "never". This finding confirmed that currently the most popular numeracy

Apps lack cognitive development and pedagogies. As suggested by Haugland (2000), when selecting software for young children it should be open-ended, child driven, and build critical thinking skills and avoid drill and practice style activities. Therefore, early childhood stakeholders need to be aware that the majority of popular numeracy based Apps for preschool education are instructive, drill and practice styled, that serve to refine existing skills that children have, not necessarily developing new skills.

7.4 Play

The final component element for discussion to determine if the use of digital technologies constitutes the early childhood pedagogy of play and therefore meeting the tenets of the proposed Digital Play model (see Figure 7.1) is children's use of digital technologies within a play-based setting. This section addresses children's level of engagement, enjoyment and their ability to learn numeracy concepts using gestural interface devices. The next section addresses these in relation to the findings, current literature and whether children's play with digital technologies can constitute digital play.

7.4.1 Engagement of Children

Kishida and Kemp (2006) state that measuring children's engagement during environmental interactions can measure children's learning outcomes as well as program quality within the early years. Therefore, young children's engagement levels were measured in the present study via the use of the nine areas in the Laevers Child Involvement Scale reported in DECS (2008), being: (1) concentration, (2) energy, (3) complexity/creativity, (4) facial expression and posture (non-verbals), (5) persistence, (6) precision, (7) reaction, (8) verbal utterances/language, and (9) satisfaction, as well as a general ranking for each observation rated from 0 (no engagement) to 5 (high engagement) in children's engagement. The results within this study showed a consistently high level of engagement within general ranking throughout the study, confirming Attard and Northcote (2011), Blake et al. (2012) and Riconscente (2013) assumption that the use of digital technology is an engaging experience for young children. The high level of engagement by children within this study clearly demonstrates that iPads can be used as a tool to engage children within their learning. A number of elements emerged in terms of children's engagement with Apps, these will be addressed to consider why children's engagement within the study varied.

7.4.1.1 Factors effecting engagement with digital technology

Four-year-old children rated higher in “precision” and “reaction time” when playing than 3 year old children; and rated higher than 3 year olds in their overall general ranking in engagement. Laevers (2000) found that engagement only occurs for children when the activity meets their capabilities. As children within this age range are developing rapidly, there is a considerable difference between the fine motor control of a 3 year old as compared to a 4 year old (Marotz & Allen, 2013). Within the early years, fine muscle development lags behind gross motor development, hence a need for a practice of such skills, which is another potential benefit of using gestural interface devices (Bower, 2012; Merchant, 2014). Moreover, with the developing capacities of children within the early years it is pertinent to note that as the children age the use of a gestural interface becomes easier and more effective. Children are able to refine motor skills, leading to higher outcomes (Dodge et al., 2002).

The refinement of fine motor skills links to the use of trial and error within gameplay. Although this use can be seen in some explorative Apps, it is very commonly seen in drill-and-practice Apps. As Varol and Colburn (2007) state, young children can practice and learn their numeracy skills via drill-and-practice programs, and the use of trial and error increases the level of participation and interests from young children. Whilst it is certainly not optimal for children to solve numerical problems by trial and error process alone, it highlights that with the more effective use of the gestural interface screen, trial and error allows children to quickly solve the numerical problem and learn from effective feedback. It is then up to the design of the software to ensure that trial and error does not reward the participant by moving them to higher levels if they only rely on trial and error to solve problems, thereby guessing rather than thinking through a problem. As described by Falloon (2013, p. 519), App design should incorporate formative, corrective feedback as well as combining an appropriate blend of game, practice and learning components. Whilst Highfield (2010) agrees that technologically based tools allow for exposure to a wider range of numeracy ideas, it does not however mean that children will grasp these ideas; in fact, they may just wash over the children without application or understanding. Therefore, educators must ensure that the selection of software as a pedagogical tool meets the children’s current stage of numerical development; otherwise children will learn strategies that make them “better at gameplay” but

not the numeracy skills the educator is attempting to promote. A level of scaffolding is needed by educators to ensure that this does not happen.

In opposition to the practices of trial and error, when children used the gestural interface appropriately they had higher levels of engagement. Anderson et al. (2004) state that a tablet computer is a gestural-based mobile computer, and it allows users to manipulate software via physical interaction, because it "features a large, high-precision, touch-sensitive display that requires no physical force" (Apple, 2011). That children showed higher levels of engagement when using the gestural interface suitably supports the statement that the use of gestural interface devices is an appropriate hardware choice for young children's engagement during learning. Within the scope of human abilities, gestural interactions using digital devices are based on the theory of embodiment, that cognition is affected by our interaction with the environment. Embodied interaction using gestural interfaces involves more of our senses than traditional (mouse-based) interfaces, and includes touch and physical movement, which are thought to help retain the knowledge that is being required (Goldin-Meadow et al., 2009). As to the relationship between the use of iPads and gestural interface devices, the findings from this study confirmed Wigdor and Segal's (2011) suggestion that gestural interface devices could benefit children's learning in contrast to a mouse and keyboard. The gestural interface provided by iPads can be leveraged better with children's learning needs (Chan & Black, 2006; Saffer, 2009; Wigdor & Wixon, 2011). This study found that the predominant digital technologies accessed within child care settings were standard desktop/laptop computers. This study demonstrates that integration of gestural interface devices into practice is likely to be far more effective in children's learning than previous technologies, particularly if educators scaffold children to use the interface. Using gestural interface to assist in problem solving is further supported by the theory of embodied cognition.

7.4.1.2 External factors effecting children's engagement with digital technology

When children's access to digital technologies at home was compared to their engagement levels, results showed that children's prior exposure to digital technologies led to higher levels of engagement. The primary exception to this was that children who had access to video games at home were rated lower in the area of "persistence" in the Engagement Scale. Hence, the more exposure children have with quality digital technologies the greater their

ability to utilise the learning tools, leading to higher levels of engagement. Integration of digital technologies into child care will allow for a greater number of children to have prior experience with digital technologies, which will optimise their potential learning when transitioning to school, where these tools are more commonly used for learning.

This study also found that the higher parents' self-reported skills in using technology, the higher their children's level of engagement whilst engaged in digital technology. This self-reported confidence can manifest itself within the skills and aptitudes parents present to children in terms of the role and value of digital technology in children's lives. Accordingly, the attitudes and beliefs held by parents can influence children's engagement with digital technology. This implies that it is important to consider the mediating impact of attitudes in the influence process of educational practices and it is particularly true when educational innovations, such as the implementation of digital play, are co-opted in young children's education environments (Bryderup & Kowlski, 2002; Kerckaert et al., 2015; Shapka & Ferrari, 2003; Tearle, 2003; van Braak et al., 2004; van der Linden et al., 2015). This finding confirms the statement of Goldspink et al., (2008) that engagement involves behaviours, such as persistence, effort and attention, as well as involving attitude, such as motivation, positive learning values, enthusiasm, interest and pride in success. This finding suggests a need for early childhood stakeholders to up-skill themselves in digital technology use. This has the potential to impact children's ability to engage with digital devices in educational settings.

7.4.1.3 Social and emotional engagement and digital play.

Whilst the major findings showed that children's engagement rated medium to high during iPad use across eight areas within the Engagement Scale, the verbal utterances/language area only rated from low to medium engagement, confirming fears about the levels of social interaction between children. Digital technology is feared to be addictive and socially isolating, fostering negative social and emotional outcomes, inhibiting language development and developing poor communication skills (needed for school and beyond) (Bower, 2013; Brown et al., 2012; Finegan & Austin, 2002; McCarrick & Li, 2007; Plowman & McPake, 2013; Plowman & Stephen, 2003; Struppert et al, 2010; Yelland, 2011). In addition, parents in this study indicated that they did not believe children's social and emotional development would benefit from digital technology use. Whilst verbal utterances were the lowest reported

area within the Involvement Scale, this does not however mean that children were not engaging socially. Analysis of the additional notes showed many interactions between children. Furthermore, when children interacted socially, their levels of engagement increased significantly (see Section 6.9.6.3). These findings challenge previous research that found that digital technology has a negative effect on preschoolers' social and emotional development (Brown et al. 2012; Tokmak 2013). Conversely, the findings from this study supports the assertions of Plowman and McPake (2013) and Yelland et al. (2014) that, with the right support, digital technologies can open up communication and allow children to develop new communication skills. It is imperative for educators to be trained in how to best utilise digital technologies within play-based care settings to offset any potential social and emotional concerns.

Children's use of iPads was observed in a naturalistic play scenario and demonstrated that when children are allowed to "play" with digital technologies they do indeed interact socially, as they would with other solitary activities such as puzzles (Heft & Swaminathan, 2002; Muller & Perlmutter, 1985; Shahrimin & Butterworth 2002). Furthermore, the current study found that there were a variety of social interactions observed. It allowed participants to be exposed to a variety of different socially engaging situations in which they were learning to modify and complement their own and others' social and emotional development and general learning, whilst interacting with digital technology. There is a dichotomy of relevant information presented within this study that juxtaposes the fear of the impact of digital technology on social development and the realities within practice. Early childhood stakeholders need to be aware that there are relevant concerns of digital technology for children's social development which however, if scaffolded appropriately, can be negated to allow for socially stimulating play.

7.4.2 Enjoyment of Children

'Enjoyment' or 'fun' are terms often used by early childhood educators when describing young children's engagement with digital technology. Green et al. (2004) define enjoyment as a 'pleasurable affective response to a stimulus'. In the current study, it was found that that playing with an iPad was rated significantly higher after playing with it. Based upon early childhood pedagogies that within early childhood settings, play and learning are woven

together (Ebbeck & Waniganayake, 2010), the finding concurs with the statement from Fleer (2013) and Gonzalez-Mena (2013) that although children may not show physical signs of enjoyment, such as smiling while they are involved or engaged in an activity, they still have a sense of enjoyment from the activity. Bower (2013, p. 5), suggests that 'iPads are fun to use, can make learning more exciting and enriching and support and enhance traditional learning'. Therefore, children's engagement and enjoyment of digital technology can be seen as a way to enrich children's cognitive development and promote curricula outcomes (Kucirkova et al., 2014). Early childhood stakeholders can use the enjoyable and fun element of digital technology to enhance a pleasurable experience that is intrinsically motivating for young children.

7.4.3 Gestural Interface Device and Its Games and Children's Ability to Learn Numeracy Concepts

Within Phase 3 of the current study, children were engaged and enjoyed the use of iPads during play with numeracy Apps. Children's numeracy abilities were tested in five areas of: (a) numeral identification, (b) counting, (c) arithmetic problems, (d) shape identification, and (e) patterns; paired t-tests; Wilcoxon signed-rank tests were used to further analyse the results. Findings revealed that all the five areas of numeracy abilities were improved after playing the highest-rated numeracy Apps via the gestural interface device. The improvement in children's numeracy scores in all five areas in all the child care centres demonstrates that numeracy Apps, via a gestural interface, are indeed an appropriate tool for teaching children numeracy skills within a play-based early childhood setting. This further demonstrates that digital technology can be used to teach children numeracy-based outcomes. The Apps used in Phase 3 were established to be developmentally appropriate as ranked within GIARS, which highlights that selecting developmentally appropriate Apps supports children's learning. This data allows early childhood stakeholders to validate the use of digital technologies within service delivery as long as the Apps selected are developmentally appropriate for use.

In the Early Years Learning Framework, numeracy in early childhood education includes "understanding about numbers, patterns, measurement, spatial awareness and data as well as mathematical thinking, reasoning and counting" (DEEWR, 2009, p. 46). The results from this study support DEEWR's (2009) statement that children can use ICTs to investigate and

problem solve, as children strengthen a range of skills and processes to enhance numeracy learning. Highfield (2010), as well as Powell and Ray (2012), describe that the use of technologically based tools can assist children to learn numerical concepts and conceptual skills such as patterning, units of area and length, ration and proportion, number and spatial awareness whilst utilising problem solving strategies and virtual manipulatives. The younger age group in this study, 3-year-olds, learnt more than the older 4-year-olds. This strengthens positions such as Haughland's (2000) assertion that by 3 years old, children are developmentally ready to use technology. Furthermore, with the advent of gestural interfaces, investigating views that interactive media is acceptable for children under 2 would open up the potential for engaging learning for very young children (Donahoo, 2014). Regardless of age, the results from this study indicated that 3 and 4 year old children did indeed learn and that this learning can be associated to two primary factors, these being: (1) the use of the gestural interface and (2) associated numeracy Apps. These two factors will be discussed in relation to the potential benefit for young children's numeracy learning.

The first primary factor is that in this study children were using a gestural interface device to learn numeracy concepts. Gestural interfaces allow for embodied interactions, which links appropriately to the way young children learn numeracy via gestures with their hands and fingers (Riconscente, 2013). In this study children did improve their numeracy outcomes, which could be explained as gestural interface devices requiring young children to use their fingers in naturalistic ways (Wasner et al., 2013). For example, gestures such as finger counting are used by young children to comprehend as a problem solving tool (Carlson et al., 2007) and gesturing while learning new numeracy concepts aid in retaining knowledge and solving problems (Goldin-Meadow et al., 2009). Therefore early childhood stakeholders should be aware that gestural interface devices do require developmentally appropriate practice within young children's numeracy learning and in this study have led to improvements in numeracy outcomes. Of course the associated Apps to the gestural interface device need to utilise the platform appropriately to gain full benefit.

Appropriately designed Apps utilising the gestural interface allow for children to be engaged learners, which in this study translated into successful numeracy learning outcomes. The results from this study support the concept that appropriate software is successful in

integrating learning and motivation (Kucirkova et al., 2014; Lee, 2015). Apps used in this study fit within the instructive component of MAAS (see Section 5.4.1), therefore are primarily drill-and-practice software, which according to Blake at al. (2012, p. 216) 'may lead to certain rote skills but not be as effective in improving children's conceptual understanding of mathematical ideas'. This study cannot prove or disprove Blake's et al. (2012) theory regarding drill-and-practice software's inability to improve conceptual understanding; however it did show that children's numeracy outcomes were improved over the duration of time that children were exposed to developmentally appropriate numeracy Apps via the iPad. In this study, the use of instructive Apps allowed children to explore and be challenged in ways that made failure a component of the learning process (such as children's continued use of trial and error within gameplay, see Section 6.9.6.1) without the consequences often associated with traditional based learning and assessment (Attard & Northcote, 2011; Risconscente, 2013). Further study would be needed to determine the long-term outcomes of the use of gestural interface devices utilising numeracy Apps on children's conceptual understanding of numeracy concepts.

There are two implications about early childhood numeracy pedagogies: **One**, early childhood educators can use gestural interface devices as a developmentally appropriate pedagogical tool to teach young children numeracy concepts. This is consistent with the recommendations from AAMT and ECA (2006) that educators of young children use accepted approaches to early childhood education such as play, emergent, child-centred and child-initiated curriculum to assist young children's development of numeracy ideas. **Two,** despite utilising drill and practice style numerical learning, numeracy Apps for young children are appropriate for development of numeracy learning outcomes for preschool aged children.

7.5 Conclusion and Digital Play model

Chapter 7 has argued that the use of digital technologies has the capacity to be classified as digital play, as shown within the Digital Play model. For digital technologies to move beyond functional tools for young children's learning and become part of early childhood pedagogical vernacular, this study suggests that three primary components of early childhood

settings, play-based learning and digital technologies influence each other and can ultimately lead to digital play being integrated within early childhood settings.

The early childhood community must embrace the integration of digital technologies within early childhood services. If this does not occur, the chance of successful integration is low. Whilst early childhood documents such as the EYLF promote the use of digital technologies, they are not embedded within this document as pedagogy, rather seen as tools facilitate outcomes. Hence, if the early childhood community does not embrace digital technologies they will find alternative methods to meet learning outcomes, hence not utilising potentially transformative learning devices. As there is reported dichotomy of opinion about the use of digital technologies with young children, this is a distinct possibility. This study however, highlighted that there is an acceptance by the early childhood community towards the inclusion of digital technologies, with a gradual introduction more important than an urgent force. There is therefore a belief that digital technologies have their place in early childhood education. Furthermore, there is a strong belief amongst parents and educators that digital technologies allow for children's learning in a range of curricula areas and developmental domains. Whilst acceptance was evident, there were concerns about affordability of digital technologies and the staff skills to implement digital technology effectually. Therefore, in order for digital play to be a realistic early childhood pedagogical model, early childhood services need to commit to the fiscal expenditure of providing staff with the appropriate tools and training to utilise digital technologies.

A primary reason identified in this study by parents and educators for the inclusion of digital technologies, and specifically gestural interface devices, is that they align with the developmental capacities of the child. This study found that children as young as 3 were able to use iPads and the refinement of fine motor skills with age improved use, demonstrating that the hardware is certainly appropriate for young children. There were implications with the most popular numeracy Apps for preschool children, in that the pedagogical approach used was instructive in nature (Highfield & Goodwin, 2013), or drill-and-practice style learning. This form of learning does not reflect a play-based learning mode of discovery and freedom (Highfield & Goodwin, 2013). In order for digital technologies to cross into digital play, Apps will need to reflect an explorative design. It must also be noted that within this

study, drill-and-practice Apps utlising a gestural interface did enhance children's numeracy learning. Consequently, if early childhood stakeholders use digital technologies that are developmentally appropriate for their children's capacities, both in terms of motor development (i.e. gestural interface devices) and learning style (Apps selected based on the needs of the children), they have the potential to be integrated appropriately to become digital play.

In terms of children's 'play' with preschool numeracy Apps, via iPads in these natural loci, children showed high levels of engagement, enjoyment and ultimately significant levels of improvement within their numeracy learning. These results are by far the clearest indication that children's use of digital technologies has the potential to become an early childhood pedagogical norm, digital play. Educators and parents within this study believed that gestural interface devices and associated Apps were appropriate for children's learning and ultimately were proven correct in their belief. Children view adults using digital technologies on a day-to-day basis (Donahoo, 2014) and are growing up in a time where technologies are changing rapidly and becoming an important part of educational and working futures. Moreover, within children's current contexts, digital technologies are tools used to make sense of their world, one of the primary objectives of play-based learning (DEEWR, 2009; Fleer, 2013). Using digital technologies within early childhood settings allows for an appropriate integration of assistive pedagogical tools within play-based learning fitting within the Digital Play model to facilitate digital play.

The successful integration of digital technologies within early childhood settings with developmentally appropriate digital technologies and trained stakeholders will meet the tenets discussed within the Digital Play model and allow for digital technologies to cross over from 'devices to assist learning' to their own early childhood pedagogical approach, "digital play". This study has shown that there is willingness from the early childhood community for this integration and that this will evolve into engaged and enjoyable learning for children. Chapter 8 (General Conclusion) will discuss implications of this study as well as the limitations and future research recommendations.

Chapter VIII: General Conclusion

8.1 Introduction

Grounded within the Technological Pedagogical Content Knowledge [TPACK] framework (Angeli & Valanides, 2005; Mishra & Koehler, 2006), the present research sought to understand the impact of digital technology on children's learning within early childhood educational settings. It investigated early childhood stakeholders' attitudes towards the use of digital technology, three and four-year-old children's engagement with, and enjoyment of digital technology, the developmental and role of preschool numeracy Apps and whether digital technology increased children's numeracy learning outcomes. The questions within this thesis were framed within the Digital Play model (see Section 2.7.4), in that the appropriate integration of digital technologies should be considered its own form of pedagogy within the early years – digital play. Currently within early childhood there are debates as to the value and importance of digital technology in young children's lives (Blackwell et al., 2013; Zaranis et al., 2013). The acceptance of digital technology within the early childhood sector focuses on the perceived changing nature of early childhood education and fear that technology is not an appropriate tool for young children's holistic developmental learning (Hedberg & McNamara, 2002; Parette et al., 2010; Tootell et al., 2013).

To frame stakeholders' acceptance of digital play, the User Acceptance of Information Technology 2 (UTAUT2) model (Venkatesh et al., 2012) was used to evaluate the perceived integration of digital technology within children's services. When evaluating emergent digital technologies such as gestural interface devices, embodied cognition explains that young children, via the use of their direct touch sensory inputs, maximise human-computer interactions. The use of gestures thereby benefitting learning in ways that previous standard desk/laptop computers could not. As a result, the acceptance of digital play as a pedagogical approach needs to be considered in the light of advances in technology.

The chapter firstly considers the significance of the findings in relation to the successful integration of digital technology into early childhood settings. It then provides insight into the limitations of the study as well as future research implications and recommendations. Finally,

a conclusion is provided to summarise the integration of digital technologies within early childhood and if this has the potential to be its own pedagogical model.

8.2 Major Insights and Implications

This study challenges philosophical and attitudinal concerns of digital technology by constructing empirically based arguments as to the effectiveness of digital technology in early childhood settings. This research was innovative as it was the first Australian study to use a mixed methodological approach to measure both attitudinal and practical applications of emergent digital technologies within early childhood settings. This study has successfully shown that when children used developmentally appropriate digital technologies, their numeracy learning improved. These findings establish that gestural interfaces support children's numeracy learning and should be utilised both in the home and in early childhood services. This finding is particularly important for parents, educators, policy makers and creators of digital technology. It validates digital technologies, specifically the use of gestural interface devices, as appropriate tools for learning. It also contributes to the reported benefits of digital technology including increased attention span, creativity and problem solving skills, consistency, knowledge expansion and application, persistence, self-confidence and self-esteem within learning, development of metacognitive skills, mathematical skills and concept knowledge (Clements, 2002; Donahoo, 2014; Lee, 2015; Plowman & McPake, 2013; Tootell et al., 2013; Vernadkis et al., 2005).

Early childhood parents and educators believed that digital technology should be integrated into early childhood. The perceived moderating effects of age, experience and gender detailed within the UTAUT2 model (Venkatesh et al., 2012) appeared to have little bearing within this study in terms of participants' willingness to accept digital technology. Rather, the primary reasons identified by early childhood stakeholders to adopt technology related to the perceived educational benefits as well as preparing children for future work and study requirements, hence a "performance expectancy" of digital technology (Venkatesh et al., 2012). Findings from this study indicate that there is the potential for numeracy and potentially other curricula areas being improved if digital technologies are developmentally appropriate and educators are adequately trained. Using digital technology within children's services will allow educators to maximise learning opportunities for children who are

accustomed to learning via digital technologies and provide opportunities and experience for those children with limited exposure within the home. This will help alleviate a potential digital divide and benefit children's transition to school, where digital technologies are commonplace, and prepare children for their working futures.

Three clear barriers for implementing digital technology into early childhood services were included: limited funding, lack of confidence using technology as a teaching tool by staff, and limited training in using technology. Within this study there was not a correlation between educators' educational degrees and their willingness to use digital technology. Which suggests that there is not a specific cohort that needs support to integrate digital technology into child care environments, rather all members would benefit from additional training and access to emergent devices. Governments therefore need to provide financial assistance to early childhood services to integrate digital technology, including money for digital resources and training, to aid the future Australian workforce to become digital citizens. Such an initiative fits within the Federal Governments *National Innovation and Science Agenda* in relation to "embracing the digital age" (Commonwealth of Australia, 2016) and would assist in helping children develop the skills needed to ensure Australia has a workforce competent in digital technologies.

Results of this study have clearly demonstrated that young children are indeed highly engaged and enjoyed using emergent technologies such as iPads, building on the limited empirical studies available on this topic. The high levels of engagement and enjoyment demonstrated by children within this study also validate the inclusion by Venkatesh et al. (2012) of hedonic motivation within the UTAUT2 model, in that there is an enjoyment factor involved in why people engage with technology. As children learnt numeracy skills during their use of iPad it highlights to stakeholders such as educators and parents that young children's uses of emergent digital technology can transform into instructional and pedagogical effective practice. This allows stakeholders to feel confident within their own use of digital technology as an educational tool to be a viable pedagogical approach, as children who are engaged learners and enjoy their task are more likely to be productive learners. That gestural interface devices link closely to the theory of embodied cognition allows stakeholders to have an understanding of how children are able to utilise these devices as developmentally

appropriate resources for early childhood environments. However dependent on stakeholders having the training and knowledge to clearly integrate digital technology into play-based learning environments.

That only half of the most popular Apps for young children were developmentally appropriate highlights a need for App developers to consider the criteria that make Apps developmentally appropriate for young children, and try to model these within App design. It is also important that educators and parents are able to identify developmentally appropriate Apps. There are a myriad of websites that evaluate and rate Apps, often for enjoyment purposes but also educationally as well, such as the American website *Common Sense Media*. The limitations of commercial websites is that it is unlikely that parents and teachers have any expertise in identifying the learning components of each App, so the reliability of their ratings are likely to be flawed. Moreover, if these sites have links to App development companies, they are likely to hold financial bias. Whilst sites such as *Common Sense Media* are helpful for early childhood stakeholders, Australian state and territory educational authorities need to have an unbiased review website that designates the developmental appropriateness of Apps and the curricula areas they serve for an Australian early childhood market. This could be similar to the *Australian Council on Children and the Media* website, although with a stronger emphasis on the educational potential of digital technology. This would provide early childhood stakeholders with an objective insight into appropriate Apps, free from over the top claims and financial bias and reflects Australian culture and sensibilities. Again, this consolidates how young children's uses of emergent digital technology can transform into instructional and pedagogical effective practice.

8.3 Limitations of the Study

Whilst the research project provided a number of relevant insights into the integration of digital technologies within early childhood settings, there were a number of limitations within each phase of the data collection process.

8.3.1 Phase 1 - Survey Phase

The data from the survey were drawn from only 49 educators and 80 parents in South Australia and the Northern Territory in Australia, which impacts on the generalisability of the

results. However, whilst this provided rich data, surveying educators and parents nationally would provide greater insight to generate change in the early childhood sector across Australia.

8.3.2 Phase 2 - App Review Phase

Although the Apps were reviewed using GIARS and MAAS rating scales, this was done by a single researcher, and thus did not allow for inter-rater reliability.

8.3.3 Phase 3 - Child Play Phase

Children's engagement and other factors from Phase 3 were observed using the observation ratings. After data analysis, some limitations were identified. For example, recording the total number of times the children played the iPads, and for how long, would have generated richer data and have given a clearer indication as to the length of time that children actually played the device over the two-week observation period and therefore could have been analysed against engagement, enjoyment and numeracy learning. Secondly, the researcher only recoded the first App the child played during the observation. Recording each App and for how long the children played with each App, would have given further insight into the Apps that children were drawn to and a subsequent analysis of the Apps to ascertain the features of the highest used Apps. Both of these issues could have been resolved by video recording the play phase so as to explore further data via recordings.

To minimise interruption to the setting, the researcher sought staff advice as to where to situate himself and the devices during the iPad experience. The positioning should have been recorded, as the location appeared to have a direct impact on the interactivity of the experience. For example, on numerous occasions the educator would set up individual tables for iPad use with only one chair at each table, and discourage other children from interacting with the playing child. This had clear ramifications for the social engagement of the tool and further investigation is needed to identify within a play-based setting how environment impacts learning with digital technologies.

The children's play phase was conducted in a naturalistic setting. Whilst this provided data that represented children in their play-based learning environment, it was impossible to eliminate the variables that could influence data collection. Therefore a limitation of this

study was there was no attempt to alter the learning environment in any way to eliminate potential variables as would occur in a test environment.

Whilst Apps were reviewed in terms of developmental appropriateness (GIARS) and function (MAAS), the results of children's pre and post numeracy measures identified *if* children learned, not *how* they learned. The Apps within the study used an 'instructive' approach as detailed in MAAS (see Appendix L), which demonstrated that via drill-and-practice styled Apps children were able to score higher on the numeracy concepts they were tested in. Thus, this method identified whether children extended their numeracy skills, which they may have already possessed, rather than inform the researcher as to whether they may have learnt new skills. A more detailed analysis of children's prior knowledge and App gameplay would be required to answer *how* children learnt, rather than *if* they learnt.

8.4 Recommendations for Further Research

A number of research directions can be identified from the discussion of the findings in consideration of the present research. Recommendations for further investigation include:

8.4.1 Digital Technologies' National Integration within Early Childhood

A number of areas within early childhood need to be further examined to give greater scope to the current integration of digital technology into early childhood.

8.4.1.1 National attitudes

Attitudes are second order barriers to the adoption of digital play into early childhood, which can be personal limitations to the integration of digital play (Blackwell et al., 2013). Whilst the current study found that the majority of early childhood stakeholders were in favour of the integration of digital play into early childhood services, this study was only done in one state and one territory. Additional surveys gauging national attitudes of early childhood stakeholders would help to provide a more complete picture of the future of digital technology within early childhood service delivery.

8.4.1.2 Current technology use within early childhood

Within this study it was noted that no child care service used gestural interface devices within service delivery. With the rise of digital technologies available for young children, it is

important to consider how emergent digital technologies, such as those using gestural interfaces, are currently being integrated into child care centres. A further study investigating whether services are using technology as a tool for learning or as a tool for recording learning, such as taking pictures/videos of children's learning outcomes, would further contribute to current knowledge. Surveying children's services in regards to the sorts and use of digital technologies within a play-based environment would strengthen other services' concepts of how to best utilise the devices and serve as models of best practice.

8.4.1.3 Financial viability

At least half of the families within this survey were below the median of annual family income nationwide, and the inability to afford technology or the training required for effective use of digital technologies are first order barriers to the successful integration of digital technology into service delivery (Blackwell et al., 2013). A detailed analysis of the cost factors for successful integration must be addressed in light of funding afforded within early childhood services. This future research will help services determine what financial costs will be associated with digital technology integration before they commit, and therefore provide detailed goals and objectives for services when allocating budgets and fund raising.

8.4.2 Training

The current study found that educators wanted training in the use of digital technologies and parents felt that educators should be trained. Educators need to be trained in how best to implement digital technology within play-based learning environments. Educators in this study had limited technological skills compared to parents and therefore will require up-skilling in both personal digital technology skill sets and how to utilise these skills for pedagogical best practice with children. Therefore an evaluation of what training packages are available for early childhood services is required to consider if current demands can be met.

8.4.3 Review of Apps

A concern arising from the current study was that only just over half of the most popular Apps for young children's numeracy learning were considered developmentally appropriate. In light of this finding a number of research considerations should be addressed.

8.4.3.1 Further App reviews

Further reviews of current Apps available for young children should be conducted. This should be expanded into differing curricula areas and consider if they can encompass different developmental domains beyond cognition. If researchers are able to determine what constitutes developmentally appropriate Apps and what function they serve, this will assist early childhood parents and educators to decide upon which Apps are most appropriate for use with their children.

8.4.3.2 Reviewing App review websites

Research to analyse how early childhood stakeholders determine which Apps to use and what they consider quality would give insight into digital technology integration. This could include investigating current commercial App review websites and comparing their ratings and analysis against more rigorous research tools such as GIARS, MAAS, Preschool App Evaluation Guide (More & Travers 2012) or Pre-MEGa (Shoukry et al., 2015). This would allow more reputable App review sites to be recommended to educators and parents who want to know which Apps are most developmentally appropriate for use with children. This information can also help organisations such as ACECQA or state or territory education departments to facilitate their own websites or recommendations.

8.4.3.3 App developers

Finally, a review of App developer's processes for creating Apps would be valuable research. This research would need to be grounded within a model such as TPACK. This would allow for an analysis of how App developers merge the emergent technologies utilising gestural interfaces with specific early childhood content and pedagogies. Qualitative case samples could provide valuable insights into how App developers design Apps for young children and this information could assist educators and parents with how best to utilise the tools. This would create an understanding of App designers' particular pedagogical approaches which would allow early childhood stakeholders to match Apps to their own pedagogical practices within delivery of the digital technology to children. Furthermore, this could assist App developers to refine their practice as well as identify areas that need to be strengthened so as to consistently create developmentally appropriate Apps that utilise the gestural interface.

8.4.4 Gestural Interfaces for Learning

Within this study it was shown that children could use gestural interfaces, in this case iPads, to extend their numeracy outcomes. This was consistent throughout the three services and was a significant finding of this study. To expand on the knowledge gained from this study a number of research directions should be taken.

8.4.4.1 Different curricula areas

Although this study has provided clear empirical evidence that engaging with high quality numeracy Apps extended children's numeracy outcomes, there is still not enough empirical data to supports claims that digital technology does or does not improve children's learning. Expanding on the notion of more empirically based studies to test the learning potential of iPads and associated Apps, future studies should expand into different curricula areas. Within this study, numeracy was the only curricula area examined. Research shows that children use gestures in numeracy frequently as a problem-solving tool (Carlson et al., 2007), with finger counting a prime example (Wasner et al., 2013). Gestural interface devices fit appropriately with children's gestural needs within numeracy and therefore act as developmentally appropriate tools for learning. There needs to be more empirically based research in other curricular areas to see if non-numeracy learning can be impacted in the same way using gestural interfaces.

8.4.4.2 Developmental domains

Within this study it was clear that early childhood stakeholders believed that digital technology was a tool for the mind and particularly useful for cognitive tasks involved in numeracy, literacy and science. This study identified that early childhood stakeholders were accurate in their assumption in relation to children's numeracy outcomes. When looking at the holistic development of children however, it is prudent to investigate whether digital technology can be used for other domains of development. A concern of early childhood stakeholders was the perceived negative impact of digital technology on children's social development. Future studies should measure if, and to what degree, children are socially impacted by the implementation of digital technology into service delivery or within the home. This is particularly relevant in relation to mobile, hand-held devices that can be

integrated into different social settings in play-based learning environments, unlike desktop/laptop computers that are fixed within a play setting.

8.4.4.3 Gestural interfaces and embodied cognition

Further studies are needed to determine if gestural interface screens were the determining factor as to why children achieved higher numeracy outcomes. Results from this study identified that children learned, not *how* they learned. As discussed within the limitations of this study, a more detailed analysis of children's prior knowledge and App gameplay would be required to answer *how* children learnt, rather than *if* they learnt. This would need to take into account that emergent digital technologies rely on gestural interfaces that are embedded within the theoretical position of embodied cognition, in that children use gestures to make the cognitive load of learning easier.

8.4.4.4 Controlled learning environment

Within this study, semi-structured field observation was used to collect information about children's activities within a child care setting. The qualitative data from the observations were also quantified; as quantitative analysis of qualitative data can be done by coding ethnographic data and looking for emerging pattern (Silverman, 2014). Whilst observation of naturalistic settings allow for an insight into the lived experience of participants, it is difficult to control variables. As explained by Ary, Jacobs and Sorensen 'control' is defined as the "steps taken by the researcher to remove the effects of any variable(s) other than the independent variable that might influence the dependent variable' (2010, p. 639). In regards to children's numeracy learning within this study, a controlled environment would validate the argument that it was indeed the digital technology that improved children's numeracy learning, rather than other variables.

8.5 Conclusion

The study highlighted that within a play-based child care setting children were able to learn numeracy-based outcomes via iPads and associated developmentally appropriate numeracy Apps. This has implications for early childhood stakeholders and the use of gestural interface devices with young children. The high levels of engagement and enjoyment displayed by children during the play phase strengthen the argument that gestural interface devices are

indeed developmentally appropriate tools for use with young children. These results suggest that gestural interface devices should be encouraged in early childhood service delivery.

How digital technologies are integrated, both in terms of hardware and software, needs to be considered for effective integration. Gestural interface devices and emergent technology prepares children for both their future educational and working lives (Daugherty et al., 2014). Educators therefore need training in the use of emergent technologies. Services should access or supply appropriate training to maximise staff confidence and ability to scaffold children's learning in this area. There needs to be careful consideration in relation to which Apps are used with children, as many of the numeracy Apps available for children are not developmentally appropriate. Tools such as GIARS can be used to assist in the identification of appropriate Apps, as can websites such as *Common Sense Media*; however Australian-based review sites would be preferable to maximise contextual awareness of Australian children and culture.

This study contributes to the debate about the integration of digital technology within the early childhood community and argues that such integration will provide developmental and learning benefits for young children. The integration of emergent technologies should be recognised as a collaborative process between early childhood educators, parents and education authorities. Implications for such integration involve funding, educating early childhood stakeholders about the learning benefits, training, and identifying developmentally appropriate Apps. Early childhood services need to keep up with the changing technological world young children are growing up in if they are to provide optimal learning and development opportunities.

This study has shown that the use of digital technology can become its own pedagogical model within early years education, this being digital play. The positive attitudes towards digital technology integration identified by educators and parents, coupled with the high levels of engagement, enjoyment and learning displayed by 3-4 year old children highlight that the domains of early childhood, play-based learning and digital technologies can work in unison to fulfil the Digital Play model (Section 2.7.4). If this study is convincing about the value of popular instructive style Apps, the value of developmentally appropriate explorative Apps will be even more so. The use of such digital technologies does indeed constitute digital

play within the early years and has the potential to become its own model of learning and impact young children's understanding of their world.

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Appendix A – Pilot Study Educator Consent Letter

Ph.D. research – Education

Leigh Disney

E-mail: dislp001@mymail.unisa.edu.au
Tel: +61 431708329
Principal supervisor: Dr. Alan Barnes
Tel: +61 8 8302 4543
E-mail: alan.barnes@unisa.edu.au

Dear participants:

I would like to invite you to participate in the pilot-study survey of my Ph.D. research. The purpose of this study is to investigate attitudes directors have towards the current and future trends in digital technology. By digital technology I am referring to products designed for the education of children, this includes:

- Televisions,
- Educational software accessed through: desktop or laptop computers, touch screen devices (e.g. iPad),
- Gaming consoles (e.g. X-box 360), and
- Internet accessed through any of the previously listed devices.

It is expected that the outcomes of the study will provide an in-depth understanding of use of digital technology, especially touch screen technology, in early childhood education.

You are invited to complete the attached survey, which consists of two sections:

Section one: This section is to seek the background information about you such as your gender, age and so on.
Section two: This section is to investigate your attitudes about use of digital technology in early childhood education.

It will take about 10-15 minutes to complete this survey; you may withdraw from the research at any time you choose.

Only the researcher and his supervisors will have access to the project information. All the printed and electronic data will be stored in the University of South Australia according to the university's regulations.

The results are analysed statistically, and individuals are not identifiable. The researcher will take every care to remove responses from any identifying material as early as possible. Likewise individuals' responses will be kept confidential by the researcher and not be identified in the reporting of the research. However the researcher cannot guarantee the confidentiality or anonymity of material transferred by email or the internet.

If you have any questions please contact:
Leigh Disney: ph +61 431708329
dislp001@mymail.unisa.edu.au
School of Education, University of South Australia

Principal supervisor, Dr. Alan Barnes: ph + 61 8302 4543
Alan.barnes@unisa.edu.au
School of Education, Magill Campus, University of South Australia

Executive Officer of this Committee, Tel: +61 8 8302 3118; Email: vicki.allen@unisa.edu.au

THANK YOU FOR YOUR PARTICIPATION IN COMPLETING THIS QUESTIONNAIRE.

Yours sincerely,
Researcher: Leigh Disney

Consent Form

Project title: Early Childhood Stakeholders' Attitudes and 3-4 year olds' Engagement and Enjoyment with Digital Technology

Researcher's name & contact details

Leigh Disney: ph +61 431708329
dislp001@mymail.unisa.edu.au
School of Education, University of South Australia

Supervisor's name & contact details

Principal supervisor, Dr. Alan Barnes: ph + 61 8 8302 4543
Alan.barnes@unisa.edu.au
School of Education, Magill Campus, University of South Australia

- I have read the **Participant Information Letter** and the nature and purpose of the research project has been explained to me. I understand and agree to take part.

- I understand the purpose of the research project and my involvement in it.

- I understand that I may withdraw from the research project at any stage and that this will not affect my status now or in the future.

- I understand that while information gained during the study may be published, I will not be identified in the reporting of the research, and my personal results will remain confidential.

Name of participant…….....

Signed…….**Date**…….

I have provided information about the research to the research participant and believe that he/she understands what is involved.

Researcher's signature and date……...

This project has been approved by the University of South Australia's Human Research Ethics Committee. If you have any ethical concerns about the project or questions about your rights as a participant please contact the Executive Officer of this Committee, Tel: +61 8 8302 3118; Email: Vicki.allen@unisa.edu.au

Appendix B – Pilot Study Parent Consent Letter

Ph.D. research – Education

Leigh Disney

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Tel: +61 431708329

Principal supervisor: Dr. Alan Barnes

Tel: +61 8 8302 4543

E-mail: alan.barnes@unisa.edu.au

Dear participants:

I would like to invite you to participate in the pilot-study survey of my Ph.D. research. The purpose of this study is to investigate attitudes directors have towards the current and future trends in digital technology. By digital technology I am referring to products designed for the education of children, this includes:

- Televisions,
- Educational software accessed through: desktop or laptop computers, touch screen devices (e.g. iPad),
- Gaming consoles (e.g. X-box 360), and
- Internet accessed through any of the previously listed devices.

It is expected that the outcomes of the study will provide an in-depth understanding of use of digital technology, especially touch screen technology, in early childhood education.

You are invited to complete the attached survey, which consists of three sections:

Section one: This section is to seek the background information about you such as your gender, age and so on.

Section two: This section is to investigate your child/children's use of digital technology at home.

Section three: This section is to investigate your attitudes about use of digital technology in early childhood education.

It will take about 15-20 minutes to complete this questionnaire; you may withdraw from the research at any time you choose.

Only the researcher and his supervisors will have access to the project information. All the printed and electronic data will be stored in the University of South Australia according to the university's regulations.

The results are analysed statistically, and you will be asked to write down your names so as to allow for comparison to your children's playing. However, the researcher will take every care to remove responses from any identifying material as early as possible. Likewise individuals' responses will be kept confidential by the researcher and not be identified in the reporting of the research.

If you have any questions please contact:
Leigh Disney: ph +61 431708329
dislp001@mymail.unisa.edu.au
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Principal supervisor, Dr. Alan Barnes: ph + 61 8
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School of Education, Magill Campus, University of South Australia

Executive Officer of this Committee, Tel: +61 8 8302 3118; Email: vicki.allen@unisa.edu.au

THANK YOU FOR YOUR PARTICIPATION IN COMPLETING THIS QUESTIONNAIRE.

Yours sincerely,
Researcher: Leigh Disney

Consent Form

Project title: Early Childhood Stakeholders' Attitudes and 3-4-year-olds' Engagement and Enjoyment with Digital Technology

Researcher's name & contact details

Leigh Disney: ph +61 431708329
dislp001@mymail.unisa.edu.au
School of Education, University of South Australia

Supervisor's name & contact details

Principal supervisor, Dr. Alan Barnes: ph + 61 8 8302 4543
Alan.barnes@unisa.edu.au
School of Education, Magill Campus, University of South Australia

- I have read the **Participant Information Letter** and the nature and purpose of the research project has been explained to me. I understand and agree to take part.

- I understand the purpose of the research project and my involvement in it.

- I understand that I may withdraw from the research project at any stage and that this will not affect my status now or in the future.

- I understand that while information gained during the study may be published, I will not be identified in the reporting of the research, and my personal results will remain confidential.

Name of participant…….....

Signed…….**Date**…….

I have provided information about the research to the research participant and believe that he/she understands what is involved.

Researcher's signature and date……...

This project has been approved by the University of South Australia's Human Research Ethics Committee. If you have any ethical concerns about the project or questions about your rights as a participant please contact the Executive Officer of this Committee, Tel: +61 8 8302 3118; Email: Vicki.allen@unisa.edu.au

Appendix C – Educator Consent Letter for Children's Playing Phase

Letter to Educators for children's playing phase

Ph.D. research – Education

Leigh Disney

E-mail: dislp001@mymail.unisa.edu.au

Tel: +61 431708329

Principal supervisor: Dr. Alan Barnes

Tel: +61 8 8302 4543

E-mail: alan.barnes@unisa.edu.au

Dear participant:

I would like to invite your service to participate in the playing phase of my Ph.D. research project. The purpose of this study is to investigate attitudes parents have towards the current and future trends in digital technology. By digital technology I am referring to products designed for the education of children, this includes:

- Televisions,
- Educational software accessed through: desktop or laptop computers, touch screen devices (e.g. iPad),
- Gaming consoles (e.g. X-box 360), and
- Internet accessed through any of the previously listed devices.

It is expected that the outcomes of the study will provide an in-depth understanding of use of digital technology, especially touch screen technology, in early childhood education.

If you agree to take part in project, 3-4 year old children within your service will partake in a study focused on the usage of Apples iPad 2. During their use of the iPad 2, the children will be observed for levels of engagement and enjoyment as well as potential numeracy learning.

It will take four weeks to complete this project; the children may be withdraw from the research at any time they choose. The results are analysed statistically, and you will be asked to write down your children's names so as to allow for comparison to parental questionnaires. However, the researcher will take every care to remove responses from any identifying material as early as possible. Likewise individuals' responses will be kept confidential by the researcher and not be identified in the reporting of the research.

Only the researcher and his supervisors will have access to the project information. All the printed and electronic data will be stored in the University of South Australia according to the university's regulations.

If you have any questions please contact:
Leigh Disney: ph +61 431708329
dislp001@mymail.unisa.edu.au
School of Education, University of South Australia

Principal supervisor, Dr. Alan Barnes: ph + 61 8302 4543
Alan.barnes@unisa.edu.au
School of Education, Magill Campus, University of South Australia

Executive Officer of this Committee, Tel: +61 8 8302 3118; Email: vicki.allen@unisa.edu.au

A consent form is attached for you to sign if you are happy for your daughter/son to participate.

Thank you for your consideration.

Yours sincerely,

Researcher: Leigh Disney

Consent Form

Project title: Early Childhood Stakeholders' Attitudes and 3-4-year-olds' Engagement and Enjoyment with Digital Technology

Researcher's name & contact details

Leigh Disney: ph +61 431708329
dislp001@mymail.unisa.edu.au
School of Education, University of South Australia

Supervisor's name & contact details

Principal supervisor, Dr. Alan Barnes: ph + 61 8 8302 4543
Alan.barnes@unisa.edu.au
School of Education, Magill Campus, University of South Australia

- I have read the **Letter to educators for children's playing phase** and the nature and purpose of the research project has been explained to me. I understand and agree for my servuce to take part.

- I understand the purpose of the research project and children's involvement in it.

- I understand that children may withdraw from the research project at any stage and that this will not affect my children's status now or in the future.

- I understand that while information gained during the study may be published, children will not be identified in the reporting of the research, and children's personal results will remain confidential.

I hereby give consent for:

Name of service…….....

Signed……**Date**…….

I have provided information about the research to the research participant and believe that he/she understands what is involved.

Researcher's signature and date……...

This project has been approved by the University of South Australia's Human Research Ethics Committee. If you have any ethical concerns about the project or questions about your rights as a participant please contact the Executive Officer of this Committee, Tel: +61 8 8302 3118; Email: Vicki.allen@unisa.edu.au

Appendix D – Parent Consent Letter for Children's Playing Phase

Letter to Parents for children's playing phase

Ph.D. research – Education

Leigh Disney

E-mail: dislp001@mymail.unisa.edu.au

Tel: +61 431708329

Principal supervisor: Dr. Alan Barnes

Tel: +61 8 8302 4543

E-mail: alan.barnes@unisa.edu.au

Dear parents:

I would like to invite your daughter/son to participate in the playing phase of my Ph.D. research project. The purpose of this study is to investigate attitudes parents have towards the current and future trends in digital technology. By digital technology I am referring to products designed for the education of children, this includes:

- Televisions,
- Educational software accessed through: desktop or laptop computers, touch screen devices (e.g. iPad),
- Gaming consoles (e.g. X-box 360), and
- Internet accessed through any of the previously listed devices.

It is expected that the outcomes of the study will provide an in-depth understanding of use of digital technology, especially touch screen technology, in early childhood education.

If you agree for your child to take part in project, your son/daughter will partake in a study focused on the usage of Apples iPad 2. During their use of the iPad 2, your son/daughter will be observed for levels of engagement and enjoyment as well as potential numeracy learning.

It will take four weeks to complete this project; your daughter/son may withdraw from the research at any time she/he chooses. The results are analysed statistically, and you will be asked to write down your children's names so as to allow for comparison to parental questionnaires. However, the researcher will take every care to remove responses from any identifying material as early as possible. Likewise individuals' responses will be kept confidential by the researcher and not be identified in the reporting of the research.

Only the researcher and his supervisors will have access to the project information. All the printed and electronic data will be stored in the University of South Australia according to the university's regulations.

If you have any questions please contact:
Leigh Disney: ph +61 431708329
dislp001@mymail.unisa.edu.au
School of Education, University of South Australia

Principal supervisor, Dr. Alan Barnes: ph + 61 8302 4543
Alan.barnes@unisa.edu.au
School of Education, Magill Campus, University of South Australia

Executive Officer of this Committee, Tel: +61 8 8302 3118; Email: vicki.allen@unisa.edu.au

A consent form is attached for you to sign if you are happy for your daughter/son to participate.

Thank you for your consideration.
Yours sincerely,
Researcher: Leigh Disney

Consent Form

Project title: Early Childhood Stakeholders' Attitudes and 3-4-year-olds' Engagement and Enjoyment with Digital Technology

Researcher's name & contact details

Leigh Disney: ph +61 431708329
dislp001@mymail.unisa.edu.au
School of Education, University of South Australia

Supervisor's name & contact details

Principal supervisor, Dr. Alan Barnes: ph + 61 8 8302 4543
Alan.barnes@unisa.edu.au
School of Education, Magill Campus, University of South Australia

- I have read the **Letter to Parents for children's playing phase** and the nature and purpose of the research project has been explained to me. I understand and agree for my child/ren to take part.

- I understand the purpose of the research project and my child/ren's involvement in it.

- I understand that my child/ren may withdraw from the research project at any stage and that this will not affect my child/ren's status now or in the future.

- I understand that while information gained during the study may be published, my child/ren will not be identified in the reporting of the research, and my child/ren's personal results will remain confidential.

I hereby give consent for:

Name of participant (child's name)…….....

Signed…….**Date**…….

I have provided information about the research to the research participant and believe that he/she understands what is involved.

Researcher's signature and date……...

This project has been approved by the University of South Australia's Human Research Ethics Committee. If you have any ethical concerns about the project or questions about your rights as a participant please contact the Executive Officer of this Committee, Tel: +61 8 8302 3118; Email: Vicki.allen@unisa.edu.au

Appendix E – Educator Consent Letter

Ph.D. research – Education

Leigh Disney

E-mail: dislp001@mymail.unisa.edu.au

Tel: +61 431708329

Principal supervisor: Dr. Alan Barnes

Tel: +61 8 8302 4543

E-mail: alan.barnes@unisa.edu.au

Dear participants:

I would like to invite you to participate in the survey of my Ph.D. research. The purpose of this study is to investigate attitudes directors have towards the current and future trends in digital technology. By digital technology I am referring to products designed for the education of children, this includes:

- Televisions,
- Educational software accessed through: desktop or laptop computers, touch screen devices (e.g. iPad),
- Gaming consoles (e.g. X-box 360), and
- Internet accessed through any of the previously listed devices.

It is expected that the outcomes of the study will provide an in-depth understanding of use of digital technology, especially touch screen technology, in early childhood education.

You are invited to complete the attached survey, which consists of two sections:

Section one: This section is to seek the background information about you such as your gender, age and so on.

Section two: This section is to investigate your attitudes about use of digital technology in early childhood education.

It will take about 10-15 minutes to complete this survey; you may withdraw from the research at any time you choose.

Only the researcher and his supervisors will have access to the project information. All the printed and electronic data will be stored in the University of South Australia according to the university's regulations.

The results are analysed statistically, and individuals are not identifiable. The researcher will take every care to remove responses from any identifying material as early as possible. Likewise individuals' responses will be kept confidential by the researcher and not be identified in the reporting of the research. However the researcher cannot guarantee the confidentiality or anonymity of material transferred by email or the internet.

If you have any questions please contact:
Leigh Disney: ph +61 431708329
dislp001@mymail.unisa.edu.au
School of Education, University of South Australia

Principal supervisor, Dr. Alan Barnes: ph + 61 8302 4543
Alan.barnes@unisa.edu.au
School of Education, Magill Campus, University of South Australia

Executive Officer of this Committee, Tel: +61 8 8302 3118; Email: vicki.allen@unisa.edu.au

THANK YOU FOR YOUR PARTICIPATION IN COMPLETING THIS QUESTIONNAIRE.

Yours sincerely,
Researcher: Leigh Disney

Consent Form

Project title: Early Childhood Stakeholders' Attitudes and 3-4-year-olds' Engagement and Enjoyment with Digital Technology

Researcher's name & contact details

Leigh Disney: ph +61 431708329
dislp001@mymail.unisa.edu.au
School of Education, University of South Australia

Supervisor's name & contact details

Principal supervisor, Dr. Alan Barnes: ph + 61 8 8302 4543
Alan.barnes@unisa.edu.au
School of Education, Magill Campus, University of South Australia

- I have read the **Participant Information Letter** and the nature and purpose of the research project has been explained to me. I understand and agree to take part.

- I understand the purpose of the research project and my involvement in it.

- I understand that I may withdraw from the research project at any stage and that this will not affect my status now or in the future.

- I understand that while information gained during the study may be published, I will not be identified in the reporting of the research, and my personal results will remain confidential.

Name of participant…….....

Signed…….**Date**…….

I have provided information about the research to the research participant and believe that he/she understands what is involved.

Researcher's signature and date……...

This project has been approved by the University of South Australia's Human Research Ethics Committee. If you have any ethical concerns about the project or questions about your rights as a participant please contact the Executive Officer of this Committee, Tel: +61 8 8302 3118; Email: Vicki.allen@unisa.edu.au

Appendix F – Parent Consent Letter

Ph.D. research – Education

Leigh Disney

E-mail: dislp001@mymail.unisa.edu.au

Tel: +61 431708329

Principal supervisor: Dr. Alan Barnes

Tel: +61 8 8302 4543

E-mail: alan.barnes@unisa.edu.au

Dear participants:

I would like to invite you to participate in the survey of my Ph.D. research. The purpose of this study is to investigate attitudes directors have towards the current and future trends in digital technology. By digital technology I am referring to products designed for the education of children, this includes:

- Televisions,
- Educational software accessed through: desktop or laptop computers, touch screen devices (e.g. iPad),
- Gaming consoles (e.g. X-box 360), and
- Internet accessed through any of the previously listed devices.

It is expected that the outcomes of the study will provide an in-depth understanding of use of digital technology, especially touch screen technology, in early childhood education.

You are invited to complete the attached survey, which consists of three sections:

Section one: This section is to seek the background information about you such as your gender, age and so on.

Section two: This section is to investigate your child/children's use of digital technology at home.

Section three: This section is to investigate your attitudes about use of digital technology in early childhood education.

It will take about 15-20 minutes to complete this questionnaire; you may withdraw from the research at any time you choose.

Only the researcher and his supervisors will have access to the project information. All the printed and electronic data will be stored in the University of South Australia according to the university's regulations.

The results are analysed statistically, and you will be asked to write down your names so as to allow for comparison to your children's playing. However, the researcher will take every care to remove responses from any identifying material as early as possible. Likewise individuals' responses will be kept confidential by the researcher and not be identified in the reporting of the research.

If you have any questions please contact:
Leigh Disney: ph +61 431708329
dislp001@mymail.unisa.edu.au
School of Education, University of South Australia

Principal supervisor, Dr. Alan Barnes: ph + 61 8
Alan.barnes@unisa.edu.au
School of Education, Magill Campus, University of South Australia

Executive Officer of this Committee, Tel: +61 8 8302 3118; Email: vicki.allen@unisa.edu.au

THANK YOU FOR YOUR PARTICIPATION IN COMPLETING THIS QUESTIONNAIRE.

Yours sincerely,
Researcher: Leigh Disney

Consent Form

Project title: Early Childhood Stakeholders' Attitudes and 3-4-year-olds' Engagement and Enjoyment with Digital Technology

Researcher's name & contact details

Leigh Disney: ph +61 431708329
dislp001@mymail.unisa.edu.au
School of Education, University of South Australia

Supervisor's name & contact details

Principal supervisor, Dr. Alan Barnes: ph + 61 8 8302 4543
Alan.barnes@unisa.edu.au
School of Education, Magill Campus, University of South Australia

- I have read the **Participant Information Letter** and the nature and purpose of the research project has been explained to me. I understand and agree to take part.

- I understand the purpose of the research project and my involvement in it.

- I understand that I may withdraw from the research project at any stage and that this will not affect my status now or in the future.

- I understand that while information gained during the study may be published, I will not be identified in the reporting of the research, and my personal results will remain confidential.

Name of participant…….....

Signed…….**Date**…….

I have provided information about the research to the research participant and believe that he/she understands what is involved.

Researcher's signature and date……...

This project has been approved by the University of South Australia's Human Research Ethics Committee. If you have any ethical concerns about the project or questions about your rights as a participant please contact the Executive Officer of this Committee, Tel: +61 8 8302 3118; Email: Vicki.allen@unisa.edu.au

Appendix G – Educator Pilot Study Survey

Pilot Study Survey for Educators

Section I Background

There are 7 questions in this section that seek background information about you. Please respond to all the questions by placing a √ in the appropriate box or typing/writing numbers in the spaces provided. This section would take about two minutes of your time.

1. Please indicate your gender by placing a √ in the appropriate box.

   ☐ **Male** ☐ **Female**

2. By placing a √ against one of the following, please indicate the age group to which you belong:

   ☐ **18-29 years** ☐ **30-39 years** ☐ **40- 49 years**

   ☐ **50-59 years** ☐ **Over 60 years**

3. Please indicate the state/territory of your child care centre by postcode ___ ___ ___ ___.

4. How many years and/or months have your worked in this child care centre?

   ☐ **Years** ☐ **Months**

5. What is your job title within the child care centre you work, for example, team leader, qualified staff member, relief staff member, etc.

   _____
   _____
   _____

6. What is your highest qualification in regards to your work?

   ☐ **High school** ☐ **Certificate** ☐ **Diploma** ☐ **Bachelor** ☐ **Postgraduate**

7. In terms of your own skills and experience in using technology you are?

   Non-User ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 **Expert-User**

Section II Attitudes towards Digital technology

By digital technology I am referring to technological products designed for the education of children, this includes:

- Television programs,
- Educational software accessed through: desktop or laptop computers, touch screen devices (e.g. iPad),
- Gaming consoles (e.g. X-box 360), and
- Internet accessed through any of the previously listed devices.

There are 12 questions about the use and potential use of digital technology in your teaching practice. Please respond to all the questions by placing a √ in the appropriate box or typing/writing number/words in the spaces provided. This section would take about five minutes of your time.

8. What digital technology devices do you currently have in your room within the child care centre you work? Please list the devices used with children.

_____
_____
_____
_____

9. Do you believe that the introduction of digital technology into early childhood education is a/an

☐	ority
☐	f secondary importance
☐	sary at all

10. Regarding the prospect of the integration of digital technology into your service, are you

☐	enthusiastic
☐	do you have reservations
☐	is your attitude negative

Please indicate the reasons why.

_____
_____
_____

11. In your opinion, what is the most important reason for integrating digital technology into the curriculum:

☐	familiarizing children with the world of the new technologies
☐	the educational benefits to be derived by the child from the use digital technology
☐	the recreational value to the child
☐	Other, please indicate _____

12. Do you agree that digital technology can be used to teach literacy, numeracy, science, art, physical education?

	Strongly agree	**Agree**	**Disagree**	**Strongly disagree**	**Do not know**
Literacy					
Numeracy					
Science					
Art					
Physical education					

13. Do you agree that digital technology can be used promote children's development in the following domains?

	Strongly agree	**Agree**	**Disagree**	**Strongly disagree**	**Do not know**
Cognitive development					
Gross motor skills development					
Fine motor skills development					
Language development					
Social development					

14. Does the educational use of digital technology in child care:

- ☐ up grade the role of educator
- ☐ downgrade the role of the educator
- ☐ take the place of the educator
- ☐ bring about no change at all

15. Should training for educators in the use of digital technology in child care be:

- ☐ obligator
- ☐ optional
- ☐ not necessary

16. Do you agree that touch screen devices, such as Apple's iPad, are appropriate for use by children aged 3 to 4 years of age?

Strongly disagree	**Disagree**	**Do not know**	**Strongly agree**	**Strongly agree**
☐	☐	☐	☐	☐

Please explain your reasons why?

_____
_____
_____

17. Do you agree that you have sufficient funding to incorporate digital technology into your room within the child care centre?

Strongly disagree	**Disagree**	**Do not know**	**Strongly agree**	**Strongly agree**
☐	☐	☐	☐	☐

18. Do you agree that in the next five years your child care centre will have integrated a greater number of digital technology than you already posses?

Strongly disagree	**Disagree**	**Do not know**	**Strongly agree**	**Strongly agree**
☐	☐	☐	☐	☐

19. What are the biggest obstacles preventing you from incorporating more digital technology into your teaching practice with children?

_____
_____
_____

Thank you for taking the time to complete the survey.

Appendix H – Parent Pilot Study Survey

Pilot Study Survey for Parents

Section I Background

There are 9 questions in this section that seek background information about you. Please respond to all the questions by placing a √ in the appropriate box or typing/writing numbers in the spaces provided. This section would take about two minutes of your time.

1. Please indicate your gender by placing a √ in the appropriate box.

☐ **Male** ☐ **Female**

2. By placing a √ against one of the following, please indicate the age group to which you belong:

☐ **18-20 years** ☐ **21-25 years** ☐ **26-30 years**

☐ **31-35 years** ☐ **36-40 years** ☐ **41-45 years**

☐ **Over 51 years**

☐ **46-50 years**

3. Please indicate your children's age and gender.

Child	**Age**				**Gender**			
A	☐	year	☐	month	☐	boy	☐	girl
B	☐	year	☐	month	☐	boy	☐	girl
C	☐	year	☐	month	☐	boy	☐	girl
D	☐	year	☐	month	☐	boy	☐	girl
E	☐	year	☐	month	☐	boy	☐	girl

4. Please indicate your state/territory by your postcode ___ ___ ___ ___.

5. What is your highest qualification?

☐ **Primary school** ☐ **High school** ☐ **Certificate – diploma** ☐ **Bachelor** ☐ **Postgraduate**

6. What is the primary language spoken in your home? _____

7. What is your total household annual income range?

Below 10,000	
10,000-19,999	
20,000-29,999	
30,000-39,999	
40,000-49,999	
50,000-59,999	
60,000-69,999	
70,000-79,999	
80,000-89,999	
90,000-99,999	
100,000-149,999	

Above 150,000	

8. Do you have any of the following digital technology tools? How often are they used in your home, including you and your children? By digital technology I am referring to technological products designed for the education of children, this includes:

- Television programs,
- Educational software accessed through: desktop or laptop computers, touch screen devices (e.g. iPad),
- Gaming consoles (e.g. X-box 360), and
- Internet accessed through any of the previously listed devices.

	Never	**Occasionally**	**Very often**	**Not owned**
Desktop computer				
Laptop computer				
Touch screen devices (e.g. iPad or tablet)				
Gaming consoles (e.g. X-box 360 or Nintendo DS)				
Internet				
Television				

9. In terms of your own skills in using technology you are?

Non-User	1	2	3	4	5	**Expert User**

Section II Your child/children's use of Digital technology at home

There are 2 questions about use of digital technology in your home. Please respond to all the questions by placing a √ in the appropriate box or typing/writing numbers in the spaces provided. This section would take about two minutes of your time.

10. When deciding if a new digital technology (e.g. computer games, television programmes, DVD's etc) is appropriate for my child, I:

☐ **Watch/play the product for the first couple of minutes to determine if the product is appropriate**

☐ **Watch/play the entire program with my child**

☐ **Watch/play the entire program by myself before I allow my child to watch/play**

☐ **Apply the ratings system provided by the product (e.g. G, PG, M etc)**

☐ **Other e.g. product advertising**

Please indicate the reasons.

_____

_____

_____

11. I monitor the digital technology (e.g. computer games, television programmes, DVD's etc) that my child is exposed to…

☐ **Very strictly**

☐ **Moderately**

☐ **Loosely**

Please indicate the reasons.

_____
_____
_____

Section III Attitudes about Use of Digital technology in Early Childhood Education

There are 11 questions about the use and potential use of digital technology with your children in a child care setting. Please respond to all the questions by placing a √ in the appropriate box or typing/writing number/words in the spaces provided. This section would take about five minutes of your time.

12. Do you believe that the introduction of digital technology into early childhood education is a/an

☐ urgent priority
☐ a matter of secondary importance
☐ not necessary at all

13. Regarding the prospect of the integration of digital technology into your service, are you

☐ enthusiastic
☐ do you have reservations
☐ is your attitude negative

Please indicate the reasons why.

_____
_____
_____

14. In your opinion, what is the most important reason for integrating digital technology into the curriculum:

☐ familiarizing children with the world of the new digital technologies
☐ the educational benefits to be derived by the child from the use digital technology
☐ the recreational value to the child
☐ Other, please indicate _____

15. Do you agree that digital technology can be used to teach literacy, numeracy, science, art, physical education?

	Strongly agree	**Agree**	**Disagree**	**Strongly disagree**	**Do not know**
Literacy					
Numeracy					
Science					
Art					
Physical education					

16. Do you agree that digital technology can be used promote children's development in the following domains?

	Strongly agree	**Agree**	**Disagree**	**Strongly disagree**	**Do not know**
Cognitive development (the child's ability to learn and solve problems)					
Gross motor skills development (This is the child's ability to use large muscles)					
Fine motor skills development (This is the child's ability to use small muscles, specifically their hands and fingers)					
Language development (This is the child's ability to both understand and use language)					
Social development (the child's ability to interact with others, including helping themselves and self-control**)**					

17. Do you agree that the use of digital technology in child care will replace the role of educators?

Strongly disagree	**Disagree**	**Do not know**	**Strongly agree**	**Strongly agree**
☐	☐	☐	☐	☐

Please explain your reasons why?

_____
_____
_____

18. Do you agree that it is necessary for educators in a child care environment to be trained in the use of digital technology with young children?

Strongly disagree	**Disagree**	**Do not know**	**Strongly agree**	**Strongly agree**
☐	☐	☐	☐	☐

Please explain your reasons why?

_____
_____
_____

19. Do you agree that touch screen devices, such as Apple's iPad, are appropriate for use by children aged 3 to 4 years of age?

Strongly disagree	**Disagree**	**Do not know**	**Strongly agree**	**Strongly agree**
☐	☐	☐	☐	☐

Please explain your reasons why?

_____
_____
_____

Thank you for taking the time to complete the survey.

Appendix I – Educator Survey (Main Study)

Survey for Educators

Section I Background

There are 8 questions in this section that seek background information about you. Please respond to all the questions by placing a tick in the appropriate box or typing/writing numbers in the spaces provided. This section would take about two minutes of your time.

1. Please indicate your gender:

☐ Male ☐ Female

2. Please indicate the age group to which you belong:

☐ 18-29 years ☐ 30-39 years ☐ 40- 49 years

☐ 50-59 years ☐ Over 60 years

3. Please indicate the state/territory of your child care centre by postcode ___ ___ ___ ___.

4. How many years and/or months have you worked in this child care centre?

☐ Years ☐ Months

5. What is your job title within the child care centre you work, for example, team leader, qualified staff member, relief staff member, etc._____

6. What is your highest qualification in regards to your work?

☐ High school ☐ Certificate ☐ Diploma ☐ Bachelor ☐ Postgraduate

7. Are you a user of technology?

	Yes, I am
	No, I am a non-user (*Please go to Question 9*)

8. In terms of your own skills in using technology you are?

Novice User	1	2	3	4	5	Expert User

Section II Attitudes towards Digital technology

By digital technology I am referring to products designed for the education of children, this includes:

- Television programs,
- Educational software accessed through: desktop or laptop computers, touch screen devices (e.g. iPad),
- Gaming console software (e.g. X-box 360), and
- Internet access.

9. Please identify the digital technology (you can choose more than one option) <u>you</u> currently have access to that are owned by your child care centre. In addition, please select the number of times the devices are used by children in your primary room:

	Accessed within your primary room	Number of times the digital technology is used by children in your room					
		At least once a day	At least once a week	At least once a month	At least once every six months	At least once a year	Has never been used
Television							
Cable Television (Foxtel/Austar)							
DVD player/Blue Ray Player							
A laptop or desktop computer							
Video game console like an Xbox, PlayStation, or Wii							
Handheld video game player like a GameBoy, PSP, or Nintendo DS							
Smartboard							
Smartphone							
Video iPod or similar device							
Kindle, Nook or similar e-Reader							
iPad or similar tablet device							
Internet							
Other, please list_____							

Section III Attitudes about use of digital technology in early childhood education

There are 10 questions about the use and potential use of digital technology with your children in a child care setting. Please respond to all the questions by placing a √ in the appropriate box/es or typing/writing number/words in the spaces provided. This section would take about 10 minutes of your time.

10. There are 5 statements about use of digital technology (e.g., Internet, educational software, television programs, educational apps etc.) within early childhood, please choose the options that best describe your experience and attitudes.

	Strongly agree	Agree	Unsure	Disagree	Strongly disagree
In terms of educational value, I believe that the implementation of digital technology into early childhood is an urgent priority?					
I am enthusiastic regarding the integration of digital technology into my service?					
I agree that the potential use of digital technology enhances the educator's ability to teach?					
I agree that funding is sufficient to incorporate digital technology into my child care centre?					
I agree that in the next five years my child care centre will have integrated more digital technology devices than we already posses?					

11. In your opinion, what are the most important reasons for integrating digital technology into the curriculum, tick the appropriate boxes:

- ☐ familiarising children with the world of new technologies
- ☐ the curricular benefits
- ☐ the recreational value to the child
- ☐ parental expectations
- ☐ other, please indicate _____ _____

12. Should in-service training for early childhood educators in the use of digital technology be:

- ☐ mandatory and done annually
- ☐ mandatory and done when new digital technology is introduced
- ☐ optional for staff
- ☐ not necessary

13. Do you agree that digital technology can be used to teach literacy, numeracy, science, art and physical education to 3-4 year old children?

	Strongly agree	Agree	Unsure	Disagree	Strongly disagree
Literacy					
Numeracy					
Science					
Art					
Physical education					

14. Do you agree that digital technology can be used to promote 3-4 year old children's development in the following domains?

	Strongly agree	Agree	Unsure	Disagree	Strongly disagree
Cognitive development					
Gross motor skills development					

Fine motor skills development					
Language development					
Social development					

15. Do you agree that touch screen devices, such as Apple's iPad, Sony's Tablet S or Samsung's Galaxy Tab are appropriate for use by children aged 3 to 4 years of age?

Strongly agree	Agree	Unsure	Disagree	Strongly disagree
☐	☐	☐	☐	☐

Please explain your reasons?

16. An important feature of touch screen devices are Apps, how confident are you that you know what an "App" is?

☐ I am very confident that I know what an App is

	I have heard what an App is, but I'm not totally sure
	I don't know what an App is (*Please go to Question 18*)

17. Do you agree that Apps designed for preschool educational purposes are indeed assistive of children's learning?

Strongly agree	Agree	Unsure	Disagree	Strongly disagree

18. What are the most significant obstacles, which may prevent you from incorporating more digital technology into your child care facility?

19. Are there any other comments you would like to make?

Thank you for taking the time to complete the survey.

Appendix J– Parents Survey (Main Study)

Parental Survey

Section I Background

There are 10 questions in this section that seek background information about you. Please respond to all the questions by placing a √ in the appropriate box or typing/writing numbers in the spaces provided. This section would take about two to three minutes of your time.

1. Please indicate your gender.

   ☐ e ☐ ıale

2. Please indicate the age group to which you belong:

   ☐ 20 years ☐ 25 years ☐ 30 years

   ☐ 35 years ☐ 40 years ☐ 45 years

   ☐ r 51 years

   ☐ 50 years

3. Please indicate your children's name, age and gender. Starting from your youngest child to oldest

Child's Full Name	**Age**	**Gender**
A_____	☐ year ☐ month	☐ boy ☐ girl
B_____	☐ year ☐ month	☐ boy ☐ girl
C_____	☐ year ☐ month	☐ boy ☐ girl
D_____	☐ year ☐ month	☐ boy ☐ girl
E_____	☐ year ☐ month	☐ boy ☐ girl

4. Please indicate your state/territory by your postcode ___ ___ ___ ___.

5. What is your highest qualification?

☐	Primary school	☐	High school	☐	Certificate – diploma	☐	Bachelor	☐	Postgraduate

6. What is the primary language spoken in your home? _____

7. What is your total household annual income range?

Below 10,000	
10,000-19,999	
20,000-29,999	
30,000-39,999	
40,000-49,999	
50,000-59,999	
60,000-69,999	
70,000-79,999	
80,000-89,999	
90,000-99,999	
100,000-149,999	
Above 150,000	

8. Are you a user of technology?

	Yes, I am
	No, I am a non-user (*Please go to Question 10*)

9. In terms of your own skills in using technology you are?

Expert User	1	2	3	4	5	Novice User

Please move to section II

Section II Your child/children's use of digital technology at home

There are 2 questions about use of digital technology in your home. By digital technology I am referring to products designed for the education of children, this includes: television programs, educational software accessed through: desktop or laptop computers, touch screen devices (e.g. iPad), gaming consoles (e.g. X-box 360), and the Internet. Please respond to all questions by placing a √ in the appropriate box/es or typing/writing numbers in the spaces provided. This section would take about 3 minutes of your time.

10. Please identify the digital technology (you can choose more than one option) you currently have in your home and the number of times they are used by your child within your home.

	Accessed within the home	Number of times the digital technology is used by 3-4 year old within your home					
		At least once a day	At least once a week	At least once a month	At least once every six months	At least once a year	Has never been used
Television							
Cable Television (Foxtel/Austar)							
DVD player/Blue Ray Player							
A laptop or desktop computer							
Video game console like an Xbox, PlayStation, or Wii							
Handheld video game player like a GameBoy, PSP, or Nintendo DS							
Smartboard							
Smartphone							
Video iPod or similar device							

Kindle, Nook or similar e-Reader							
iPad or similar tablet device							
Internet							
Other, please list_____							

11. When deciding if a new digital technology product (e.g. computer games, television programmes, DVD's etc) is appropriate for my child, I (tick appropriate boxes):

    ☐ Watch/play the product for the first couple of minutes to determine if the product is appropriate

    ☐ Watch/play the entire program with my child

    ☐ Watch/play the entire program by myself before I allow my child to watch/play

    ☐ Apply the ratings system provided by the product (e.g. G, PG, M etc)

    ☐ Other e.g. product advertising

    Please indicate the reasons.

    _____
    _____
    _____

Please move to Section III

Section III Attitudes about use of digital technology in early childhood education

There are 11 questions about the use and potential use of digital technology with your children in a child care setting. Please respond to all the questions by placing a √ in the appropriate box/es or typing/writing number/words in the spaces provided. This section would take about 10 minutes of your time.

12. There are 4 statements about use of digital technology (e.g., Internet, educational software, television programs, educational apps etc.) within early childhood, please choose the options that best describe your experience and attitudes.

	Strongly agree	Agree	Unsure	Disagree	Strongly disagree
In terms of educational value, I believe that the implementation of digital technology into early childhood is an urgent priority?					
I am enthusiastic regarding the integration of digital technology into my child's child care centre?					
I agree that the use of digital technology in child care will replace the role of educators?					
I agree that it is necessary for educators in a child care environment to be trained in the use of digital technology with young children?					

13. In your opinion, what are the most important reasons for integrating digital technology into child care centres, tick the appropriate boxes:

☐ familiarising children with the world of new technologies

☐	the curricular and educational benefits
☐	the recreational value to the child
☐	parental expectations
☐	other, please indicate _____

14. Do you agree that digital technology can be used to teach literacy, numeracy, science, art and physical education to 3-4 year old children?

	Strongly agree	Agree	Unsure	Disagree	Strongly disagree
Literacy/Language					
Numeracy/Mathematics					
Science					
Art					
Physical education					

15. Do you agree that digital technology can be used to promote 3-4 year old children's development in the following domains?

	Strongly agree	Agree	Unsure	Disagree	Strongly disagree
Cognitive development (the child's ability to learn and solve problems)					
Gross motor skills development (This is the child's ability to use large muscles)					
Fine motor skills development (This is the child's ability to use small muscles, specifically their hands and fingers)					
Language development (This is the child's ability to both understand and use language)					

Social development (the child's ability to interact with others, including helping themselves and self-control**)**					

Please turn to final page for questions 16-20, Thank you.

16. Do you agree that touch screen devices, such as Apple's iPad, Sony's Tablet S or Samsung's Galaxy Tab are appropriate for use by children aged 3 to 4 years of age?

Strongly agree	Agree	Unsure	Disagree	Strongly disagree
☐	☐	☐	☐	☐

17. Please explain your reasons why?

_____
_____
_____

18. An important feature of touch screen devices are Apps, how confident are you that you know what an "App" is?

☐ I am very confident that I know what an App is
☐ I have heard what an App is, but I'm not totally sure
☐ I don't know what an App is (*Please go to Question 18*)

19. Do you agree that Apps designed for preschool educational purposes are indeed assistive of children's learning?

Strongly agree	Agree	Unsure	Disagree	Strongly disagree
☐	☐	☐	☐	☐

20. Are there any other comments you would like to make?

Thank you for taking the time to complete the survey and please return to the reception desk or to the staff in your child's room.

Appendix K – Gestural Interface App Rating Scale

App Rating Scale

Title	
Publisher	
Age Range	
Cost	
Date Evaluated	
Evaluated by	

Game Description	
Comments	

Age Appropriate

	Met	Partially	Not Met	Score
Realistic concepts				
Appropriate Methods				

Contextual Environment

	Met	Partially	Not Met	Score
A Clear Beginning				
Minimal Interface Elements for Content				
Sequence of Learning Present				

Spatial Design

	Met	Partially	Not Met	Score
Support Using 2				
Adhere to Principles of 3				

Seamlessness

	Met	Partially	Not Met	Score
Responds to Every Contact				
Transitions Fluid				
Single Finger Flick Movements				
No Time-based Gestures				

Scaffolding

	Met	Partially	Not Met	Score
Appropriate Action Prompting				
Functionality				
Intentional User Input				
Reversible Actions				

No Touch Left Behind

	Met	Partially	Not Met	Score
Precise Selection of Content				

The Anatomy of a Gesture

	Met	Partially	Not Met	Score
Gestures are Minimal and Immediately Clear				
Clear Feedback				

Non-Violence

	Met	Partially	Not Met	Score
App is free of violent characters and actions				
App models positive social values				

Process Orientation

	Met	Partially	Not Met	Score
Discover Learning, Not Skill Drilling				
Intrinsic Motivation				
Process Engages, Product Secondary				

Real World Model

	Met	Partially	Not Met	Score
Accurate Information				
Advertising is Minimal or Not Apparent				
Concrete Representations				
Objects Function				
Simple, Reliable Model				

Game Title_____

Final Score

Within the Gestural Interface App Rating Scale below *content* refers to the specific outcomes the App is attempting to teach (e.g. aimed at early childhood numeracy development) via the game based learning the App uses.

Gestural Interface App Rating Scale (GIARS)

Within the Gestural Interface App Rating Scale, there is a nine point checklist that addresses the following criteria: (1) age appropriate, (2) contextual environment, (3) seamlessness, (4) scaffolding, (5) no touch left behind (6) the anatomy of a gesture, (7) non-violence, (8) process orientation, and (9) real world model. Each criteria receives a score between 0 to 1, 1 being all components of the criteria met, 0.5 for partial components met, and 0 for no components met within the criteria. This gives the software a sub score out of 9. A score above 6 is considered to be developmental software. The researcher will choose the 5 highest scoring games to use within the children's playing phase of the study (see Chapter 6).

Age Appropriate

- Realistic concepts - The concepts taught by the App need to reflect realistic expectations for young children. The focus of the program is one or more sound learning objectives. These objectives are valuable skills and/or knowledge for children to acquire for the age(s) the App is designed.
- Appropriate Methods - Learning objectives are facilitated using teaching methods that reflect young children's emerging cognitive, physical, emotional and social skills. The method of teaching meets young children's developmental needs rather than children needing to adapt to meet the demands of the App. The App will recognize that children will approach the program from different developmental levels, since children's abilities in a classroom setting vary greatly.

Contextual Environment

- A Clear Beginning – An App should begin with what actions are elicited in this environmental context. For example, an App targeted at preschool aged children can begin with the environment and actions typical of that game. Within preschool education this needs to consider the pre-reading child.

- Minimal Interface Elements for Content - Children focus on content and so should the interface. The App should provide an absolute minimum number of interface elements that are required for the interaction. For some interactions there is no interface beyond the content.
- Sequence of Learning Present – The App needs to consider how interactions might be logically extended so that the new actions are easily learned and enhancing opportunity for children to achieve the expected result. Therefore, children can use the same interface elements within the App to undertake increasingly challenging content.

Seamlessness

- Responds to Every Contact – Apps should respond to every contact so the child will not wonder whether the object is broken or malfunctioning. This immediate response blurs the line between the real and the virtual. The App uses pre-buffer material, provide a transition, or use other mechanisms to make sure that every touch receives an immediate and meaningful response. An App without immediate responses detracts significantly from the user experience.
- Transitions Fluid – Apps should make every transition fluid. Every object and visible property change must smoothly animate and transition into and out of existence, or between changes. Nothing should abruptly appear or disappear.
- Single Finger Flick Movements – Apps should enable single-finger drag and flick movements on movable content. Apps must always define a single-finger drag and flick to make sure that children can always apply these basic manipulations to all content.
- No Time-based Gestures – Apps should not use time-based gestures on content. Time-based activations introduce mandatory delays for expert users, and they also detract from the sense of a natural environment.

Scaffolding

- Appropriate Action Prompting –Apps should ensure that all likely actions lead to either prompting for the next step in the action sequence or foreshadowing of the state of the system/object when the action is finished. This is best done visually with younger pre-

literate children.

- Functionality - At the appropriate time Apps should show children affordances that guide them to access the unseen content or functionality. If the user touches the content, then it should move slightly to show that it can be scrolled.
- Intentional User Input – The App should require explicit and intentional user input to activate destructive functions or to cause larger changes or transitions.
- Reversible Actions – The App should foreshadow upcoming results so that the child can reverse their actions. This includes interface details, for example, during the resize of an image, if the image is about to jump to full screen (obscuring other images), show an outline of the image or a transparent version of the image at full-screen size. The user can then either reverse and negate that action (the image will not jump to full size) or remove her fingers so that the image becomes full size. Another option is it can include content details, for example in a multi-step solution to a problem so a child can reverse their decision if they believe they have taken a wrong step.

No Touch Left Behind

- Precise Selection of Content – Apps should ensure that children are able to precisely select objects on the touch screen device. This can be done in a variety of ways, from adjusting the physical size of icons to providing techniques that enable selection of smaller content. Apps need to ensure that children can manipulate and control the interface of the App taking into account children's developing fine motor skills.

The Anatomy of a Gesture

- Gestures are Minimal and Immediately Clear – Apps should minimize the number of steps children must take to register the gesture mode. There must be a minimization of overlaps in the initial action, whatever action the child does first, make sure that as small a subset of gestures as possible uses that same first action. Apps must minimize the load required to transition between registration and continuation phases; it should be immediately clear to the child how to specify the command they want to execute.

- Clear Feedback – Apps should provide clear feedback for the child at each step, ensuring they understand when they have transitioned from registration to continuation, and how to terminate the gesture. This also includes prompting when the appropriate action is not taken and transitioning to each new step.

Non-Violence

- Apps should contain no violent objects, characters or actions. When children use Apps, they should not be exposed to violence or violent materials that children could use to perform violent actions: such as guns, swords, bombs or poison.
- Apps should model positive social values such as caring, cooperation, communication, sharing, friendship and family. Through the interaction elements between children and the digital characters, Apps should demonstrate the importance of positive social values.

Process Orientation

- Apps should promote discovery learning, not skill drilling.
- Apps should be appealing to young children, hence does it utilise visual and audio aesthetics to call children's interests.
- App gameplay features are "fun" and engaging with the process more important than the product. Children are not given extrinsic rewards such as smiley faces, tune or prizes.

Real World Model

- Accurate Information – The App gives factually accurate information to children.
- Advertising is Minimal or Not Apparent - The App does not advertise to children.
- Concrete Representations – The App attempts to represent abstract concepts in a concrete fashion, acknowledging that young children learn through concrete learning.
- Objects Function - The App goes beyond just modelling objects in the program function. Because the objects function, they provide children with a small model of the world (a

micorworld). For example, in a cooking game a blender chops food through children input.

- Simple, Reliable Model - It is important that images and there functions are simple, reliable and scaled realistically.For example, horses are larger than dogs, buildings are bigger than cars, and trees are bigger than carrots.

Appendix L – Math App Appraisal Scale

Instructions:

1. Investigate the App, thinking about its role in teaching and learning mathematics – there are no right or wrong answers.
2. Choose any of the three roles described above– *You can choose a combination where roles overlap.*
3. Go to the relevant section(s) next page 6 and 7 where specific issues are presented for your appraisal
4. Complete items on following page.

Step 1	Choose the App role(s)
Step 2	Explorative App → Go to next page: Section 3
	Productivity App → Go to next page: Section 4
	Instructive App → Go to next page: Section 5
Step 3	Complete items on following pages 4 and 5

Task Structure *Circle any of the three roles outlined below – You can choose a combination where roles overlap.*

SECTION 1: EXPLORATIVE APPS *(please check one of the options for each row)*

	Always	**To some extent**	**Never**	**Not applicable**
App closely mirrors a model or real-life situation	☐	☐	☐	☐
Children can enter their own data and observe changes in the model	☐	☐	☐	☐
Exploration is guided within a predetermined learning discovery framework	☐	☐	☐	☐
Tasks are goal oriented driving child interest and curiosity	☐	☐	☐	☐
There are elements of ambiguity and uncertainty fostering personal investigation	☐	☐	☐	☐

If you are not doing any other section please continue to next page

---

SECTION 2: PRODUCTIVITY Apps *(please check one of the options for each row)*

	Always	**To some extent**	**Never**	**Not applicable**
App lets children to creatively come up with their own design and/or concept	☐	☐	☐	☐
App allows representing maths content by linking symbolic, numerical and graphical data	☐	☐	☐	☐
Children are guided in creating their own content/understandings	☐	☐	☐	☐
Children can represent or present maths content using a variety of different tools (e.g., audio/video recording, measuring devices, etc)	☐	☐	☐	☐
App tools are intuitive and easy to use	☐	☐	☐	☐

If you are not doing any other section please continue to next page

---

SECTION 3: INSTRUCTIVE Apps *(please check one of the options for each row)*

	Always	**To some extent**	**Never**	**Not applicable**
App contains a variety of different activities/exercises	☐	☐	☐	☐
Appropriate feedback is provided to children	☐	☐	☐	☐
Activities/exercises cater for a range of child ability levels	☐	☐	☐	☐
Content is meaningful, fostering engagement and rich problem solving	☐	☐	☐	☐
App contains activities/exercises that are graded and summary data is provided	☐	☐	☐	☐

If you are not doing any other section please continue to next page

---

Cognitive Involvement

The app encourages children to … *(please check one of the options for each row)*

	Always	**To some extent**	**Never**	**Not applicable**
Retrieve and review maths concepts/skills/procedures (Remembering)	☐	☐	☐	☐
Demonstrate understanding of maths concepts/skills/procedures (Understanding)	☐	☐	☐	☐

Apply their knowledge of maths concepts/skills/procedures in practical contexts (Applying)

□ □ □ □

Critically analyse maths content in text, graphs and/or animations (Analysing)

□ □ □ □

Appraise and justify maths ideas or products (Evaluating)

□ □ □ □

Construct new and meaningful maths ideas or products (Creating)

□ □ □ □

General Pedagogical Issues

The app … *(please check one of the options for each row)*

	Always	**To some extent**	**Never**	**Not applicable**
Permits children to pose their own problems	□	□	□	□
Allows for differentiation through sequentially designed degrees of difficulty	□	□	□	□
Gives children control over their learning	□	□	□	□
Delivers content in an appealing and motivating way according to the age group	□	□	□	□
Provides meaningful teaching and learning guidelines	□	□	□	□
Integrates maths with content from other Key Learning Areas	□	□	□	□
Allows children to collect and record their own data	□	□	□	□
Shows a reading level appropriate to the children's level	□	□	□	□
Saves and keeps childrens' work	□	□	□	□
Provides opportunities for collaboration	□	□	□	□

Continue to next page …

Operational Issues

The app … *(please check one of the options for each row)*

	Always	**To some extent**	**Never**	**Not applicable**
Has an intuitive and user friendly navigation	☐	☐	☐	☐
Contains helpful technical instructions to the user and/or a Help function	☐	☐	☐	☐
Lets children alter its settings to customise the app to their needs	☐	☐	☐	☐
Allows file sharing, streaming of content and/or online communications	☐	☐	☐	☐
Is flexible permitting children to move in different directions	☐	☐	☐	☐
Has a supporting Web page providing additional useful information	☐	☐	☐	☐
Easily works with a range of media (audio, video, image, text, animations)	☐	☐	☐	☐
Can interface with social media tools (e.g., Facebook, wikis, blogs, Twitter, YouTube)	☐	☐	☐	☐
Presents an uncluttered display which is visually stimulating	☐	☐	☐	☐
Permits a child leave at any time and begin where he or she left	☐	☐	☐	☐

Write here any other comments you might have about the quality of your maths app.

-END OF THE APPRAISAL-

Appendix M – Involvement Scale

Involvement Scale: Cover sheet

Site: Child:

Number of sessions per week: Age: Sex:

Observer: Date:

RATING DESCRIPTIONS

LEVEL	OBSERVATION	
1	No activity	Aimless, absent minded
2	Frequently interrupted activity	Tinkering/dreaming
3	More or less maintained activity	Busy but routine actions without much devotion, few signals of involvement
4	Activity with intense moments	Strong involvement with interruptions/involved but not all signals
5	Sustained intense activity	Involved with essential signals (concentration, energy, complexity/creativity and persistence)

Involvement Scale: Rating sheet

Using the results from the Indicator Observations make a judgement of the global quality of each signal and assign low (l), medium (m) or high (h) for each signal.

Rating Observation 1: *Time*

Brief description of Observation Context:

Concentration	l m h		*Factors affecting observation:*
Energy	l m h		
Complexity & creativity	l m h		
Facial expression & posture	l m h		
Persistence	l m h	1 2 3 4 5	
Precision	l m h		
Reaction time	l m h		
Verbal utterances/language	l m h		
Satisfaction	l m h		

Rating Observation 2: *Time*

Brief description of Observation Context:

Concentration	l m h		*Factors affecting observation:*
Energy	l m h		
Complexity & creativity	l m h		
Facial expression & posture	l m h		
Persistence	l m h	1 2 3 4 5	
Precision	l m h		
Reaction time	l m h		
Verbal utterances/language	l m h		
Satisfaction	l m h		

Rating Observation 3: *Time*

Brief description of Observation Context:

Concentration	l m h		*Factors affecting observation:*
Energy	l m h		
Complexity & creativity	l m h		
Facial expression & posture	l m h		
Persistence	l m h	1 2 3 4 5	
Precision	l m h		
Reaction time	l m h		
Verbal utterances/language	l m h		
Satisfaction	l m h		

Involvement Scale: Rating sheet (continued)

Using the results from the Indicator Observations make a judgement of the global quality of each signal and assign low (l), medium (m) or high (h) for each signal.

Rating Observation 4: *Time*

Brief description of Observation Context:

Concentration	l m h		*Factors affecting observation:*
Energy	l m h		
Complexity & creativity	l m h		
Facial expression & posture	l m h		
Persistence	l m h	1 2 3 4 5	
Precision	l m h		
Reaction time	l m h		
Verbal utterances/language	l m h		
Satisfaction	l m h		

Rating Observation 5: *Time*

Brief description of Observation Context:

Concentration	l m h		*Factors affecting observation:*
Energy	l m h		
Complexity & creativity	l m h		
Facial expression & posture	l m h		
Persistence	l m h	1 2 3 4 5	
Precision	l m h		
Reaction time	l m h		
Verbal utterances/language	l m h		
Satisfaction	l m h		

Rating Observation 6: *Time*

Brief description of Observation Context:

Concentration	l m h		*Factors affecting observation:*
Energy	l m h		
Complexity & creativity	l m h		
Facial expression & posture	l m h		
Persistence	l m h	1 2 3 4 5	
Precision	l m h		
Reaction time	l m h		
Verbal utterances/language	l m h		
Satisfaction	l m h		

INDIVIDUAL'S MEAN SCORE: _____

Appendix N – Enjoyment Scale: Sticky Ladder Rating Chart

Participant Name/Code:

Pre-test	iPad	Painting	Play dough	Reading	Xylophone
Date:	Rank:	Rank:	Rank:	Rank:	Rank:
Post-test	iPad	Painting	Play dough	Reading	Xylophone
Date:	Rank:	Rank:	Rank:	Rank:	Rank:

Appendix O – Numeracy Scale

Numeracy Measurement and Shape Identification

Child's Name: Date: Links to obs #:

Numeral identification

Script: "In this game, I will hold up a number card and I would like you to tell me which number it is?"

Mark as tick or cross.

__ 2 __ 9__ 8__ 1__ 4__ 3__ 5 __ 7 __ 6 __ 10

Counting

Script: "This is the second game, can you count from 1-10? Ready? Go!"

"Wow, that was great counting, can you count to 100! Ready? Go!"

Cross off those numbers the child says.

1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100.

Arithmetic problems

Script: "Suppose you have N rocks and I give you M more; how many rocks would you have then?"

2 + 1____ 2 + 2 ____4 + 2 ____2 + 3____

Shape Identification

Script: "The last game, here is a book about shapes, can you tell me what shape this is?"



_____

_____ _____ _____ _____ _____ _____ _____ _____ _____

Patterns

Script: I have a pattern, can you tell me what comes next?



_____



_____

Guidelines for Numeracy and Shape Measurement Tool

Numeral identification

The task involved 10 randomly ordered cards, each with a numeral from 1 to 10 on it. On each trial, the experimenter holds up a card and asks the child to name the numeral.

Script: ”In this game, I will hold up a number card and I would like you to tell me which number it is?”

__ 2
__ 9
__ 8
__ 1
__ 4
__ 3
__ 5
__ 7
__ 6
__ 10

Counting

Children will be asked to count from 1 to 10. Counting will be coded as correct up to the first error (e.g., if a child counted “1, 2, 3, 4, 5, 6, 8, 9, 10,” her score will be 6).

Script: “This is the second game, can you count from 1-10? Ready? Go!”

If the child is able to count to 10, move to the next set of 11-20 by saying,

“Wow, that was great counting, can you count to 20! Ready? Go!”

This will be continued until the child’s first mistake or until 100.

Mark on the answers page each number that the child does not manage to count verbally (do not show him the numbers on the page).

1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100.

Arithmetic problems

The arithmetic pretest is composed of four addition problems, presented in the order: 2 + 1, 2 + 2, 4 + 2, and 2 + 3. Children will be asked:

Script: "Suppose you have N oranges and I give you M more; how many oranges would you have then?"

Shape Identification

Children will be shown a book containing the shapes below.

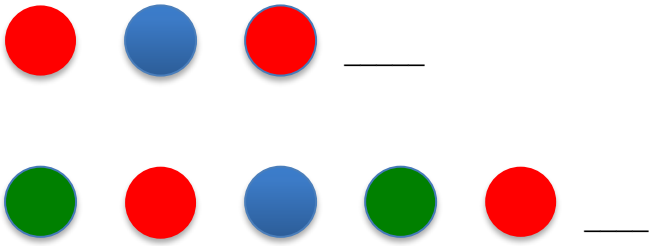
Script: "Here are some cards about shapes, can you tell me what shape this is?"



Patterns

Children will be shown a set of three patterns and asked to complete them.

Script: I have a pattern, can you tell me what comes next?



As on the other pretest, no feedback will be given.

Appendix P – Published Papers

Disney, L., Geng, G., & Barnes, A. (2015, November 30- December 4). *Early childhood educators' attitudes towards use of educational media in young children's learning in Australia*. In Ogata, H. et al. (Eds.) (2015). Proceedings of the 23rd International Conference on Computers in Education. Hangzhou China (673-678). Hangzhou, China: Asia-Pacific Society for Computers in Education

Disney, L. & Geng, G. (2014, September 30- October 3). ' Investigating 3-5 Year-Old's Parents' Attitudes towards Use of iPad', In Proceeding of 26th Australian Computers in Education Conference, (100-107), Adelaide, Australia.

Disney, L, Barnes, A, McDowall, J, & Geng, G. (2013, November 18-22), 'Observation of Children's Engagement when Playing iPads', In Ogata, H. et al. (Eds.) (2013). Proceedings of 21st International Conference on Computers in Education (ICCE2013), Bali, Indonesia (602-607), Bali, Indonesia: Asia-Pacific Society for Computers in Education .