Investigation of Young children's Use of Gestural Interface

Leigh Disney, *Monash University, Melbourne*
Gretchen Geng, *Teaching and Researching Australian English and Culture, Melbourne*

Introduction

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). Consumer studies show that Apple's iPad is the most commonly owned tablet computer within Australia (Colley, 2010; Kennedy & Nadin, 2014; Tootell, Plumb, Hadfield, & Dawson, 2013). According to Kucirkova, Messer, Sheehy, and Fernández Panadero (2014), since their release in 2010, iPads and associated Apps have become popular worldwide for a variety of users, including preschool children. Mobile and tablet technologies are part of children's lives (Chaudron et al., 2015; Highfield, 2014). A tablet computer is a gesture-based mobile computer which allows the user to manipulate software via physical interactions (Anderson et al., 2004). The 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'.

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, Cloker, & Heroman, 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. Therefore, in relation to the aforementioned 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.

An important concept within the current research is the link between cognition and physical actions. Specifically, that 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 overall selection of apps 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, Wigdor and Wixon (2011) describe what they believe to be the key elements to designing software appropriate for gestural interfaces, including contextual environments, spatial design, seamlessness, scaffolding, no touch left behind and the autonomy of a gesture. 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. Their 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, research by Nacher, Jaen, Navarro, Catala and Gonzalez (2015) highlighted that 99% of Apps used tap gestures and 56% used on tap and drag gestures as their only supported operations. However, Nacher et al. (2015) also advise that even young children are capable of more complicated gestural controls than most Apps allow for. Therefore it is important to consider both the content of that 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 (Goldin-Meadow, Cook, & Mitchell, 2009; Kucirkova et al., 2014; Yelland, Gilbert & Turner, 2014).

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. Therefore, this paper is to investigate the use of gestural interface in early childhood settings and its impact on young children's learning and engagement while playing iPads.

Methods

This research used qualitative research methodology and observation research method. Semi-structured field observation can be used as a "fundamental basis of all research methods" in social and behavioural science (Denzin & Lincoln, 2005).

Participants

Eighty children participated in this study. Children were classified as 3-4 years age group (43.8%), and 4-5 years age group (56.3%).

Instruments

The Involvement Scale *Assessing for learning and development in the early years using observation scales: Reflect respect relate*" (DECS, 2008, p. 81) was used and described 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*. Concentration, energy, complexity/creativity and persistence are four essential signals that must be present for sustained, intense involvement.

Using the Gestural Interface App Rating Scale (GIARS) developed from the Haugland Scale (Haughland & Wright, 1997), 50 early childhood numeracy Apps were also chosen from the Game Centre component of the Apple website.

Procedure

Before this phase was undertaken, letters to the participants' parents, letters to the directors and educators in child care centres were handed to the parents, directors and educators. Following this procedure, consent was obtained successfully from all parties.

All children participating in the proposed research were observed in three child care centres during their first use of the iPad2, and 5 times after for a total of 6 observations. Each observation is two-minute in duration, started at anytime whilst the child is using the iPad2 and continues. If the child leaves the iPad2 during the 2 minute observation period, the researcher continues to observe the child incase they come back to the iPad2. After a two minute observation, the researcher must take time to make notes and fill out the rating. Each observation requires a score sheet and label for each child for the 6 observations, based upon the Involvement Scale (DECS, 2008). The score sheets should not be recorded until after the observation is completed. SPSS will be used in data analysis. Data were transcribed, entered and analysed. The researcher took approximately 4 weeks to enter all the written answer in to the Statistical Package for Social Science (SPSS).

Results

Table1 presents the means and standard deviations of the nine areas in Involvement Scale. 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 1).

Table 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, $p < .01$.

The elements of Gestural Interfaces, including contextual environments, spatial design, seamlessness, scaffolding, no touch left behind and the autonomy of a gesture, 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 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.

It was also found the Elements of GI was significantly correlated with the following areas in children's engagement scale (See Table 2). 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 2: Correlations between Elements of GI 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.

Discussion and Conclusion

This study contributes to the debate about the integration of digital technology, such as gestural interface, within the early childhood community and argues that such integration will provide developmental and learning benefits for young children.
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 (Goldin-Meadow et al., 2009; Kucirkova et al., 2014; Yelland et al., 2014).

The gestural interface provided by iPads can be leveraged better with children's learning needs (Wigdor & Wixon, 2011). Gestural interfaces allow for embodied interactions, which links appropriately to the way young children learn via gestures with their hands and fingers (Stone et al., 2014). Gestures such as finger counting are used by young children to comprehend as a problem solving tool (Wigdor & Wixon, 2011).
This research also found the interactive designs of gestural interface devices are certainly appropriate for young children. 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).

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 (Barsalou, 2008; Brouillet, Ferrier, Grosselin & Brouillet, 2011). 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. 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.

Therefore this has implications for early childhood stakeholders and the use of gestural interface devices with young children. The high levels of engagement 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, Dossani, Johnson, & Oguz, 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.

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