This paper reports on a research project which investigated children’s use of touchscreens in early childhood and junior primary settings by introducing touchscreens in five classrooms in Melbourne. Several methods to obtain information about how children interacted with the touchscreens were used including observation, journals and field notes, and interviews. The research identified five key themes, relating to developmental issues, input device preference, technical issues, individual differences in children’s use of the touchscreen and issues of collaboration. This research was funded by touchscreen manufacturer MicroTouch Australia.

Introduction

Computers have become an increasingly important part of education in Australia across a range of educational settings, including the primary and early childhood sectors. The use of the computer in these settings has undergone a gradual transformation since their first appearance in the early 1960s and 1970s, when a transmission model of education informed its use. This model positioned the computer as a means of simply delivering or transmitting information to learners and was responsible for the early development of computer-based instruction or training. More recently, constructivist models of education have positioned the computer as a tool to enhance existing teaching and learning practices. This has served to emphasise the role of computers in education, challenging early notions of computer education. This repositioning of the computer as a learning tool was related to concurrent developments in educational pedagogy, which increasingly depicted the acquisition of knowledge as an active process enacted by individuals within a social context.

Based particularly on the early philosophical work of Kant, the idea that knowledge is actively constructed by the individual initially arose as a result of the convergence of rationalist and empiricist philosophical approaches. The field later underwent further development with the adoption of Piaget and Vygotsky’s descriptions of the development of intelligence in the young child. Although both of these theories described the development of intelligence in terms of competing cognitive/social devices, each argued that intelligence developed via interactions with the environment, which in turn provided the means for knowledge to be acquired. These theories were interpreted in educational circles to mean that students do not passively receive knowledge from teachers, textbooks or educational software. Rather, knowledge was viewed as arising from students’ interactions with the materials, symbols and ideas located in the external and social environments in which they engaged in learning.

In the early childhood context, constructivism has since been represented as a pedagogical approach to education referred to as developmentally appropriate practice. Its premise is that children need to engage in those learning experiences that best meet their current levels of development across a range of areas including those concerned with their social,
emotional, physical and cognitive development. Because developmentally appropriate practice emphasises the role of development in children’s learning, it argues that children need to be provided with learning experiences that are ‘concrete, real and relevant’ and that ‘allow children to actively construct their own learning’.

Computer-based learning experiences were initially seen as being in conflict with developmental approaches to early childhood education, with some writers expressing concern that the computer would displace those essential life experiences necessary to support children in their acquisition of knowledge. However, research into children’s uses of the technology began to allay these fears with findings suggesting that computers actually supported appropriate social behaviours, particularly when children were encouraged to share the computer as a resource, and to assist each other in problem solving. Further studies also found that the computer had a positive influence on the development of language and cognitive skills, such as problem solving and reasoning. Later research confirmed these findings and emphasised the role of developmentally appropriate software in supporting children’s development in the language and cognitive domains.

These findings were later given public recognition by the National Association for the Education of Young Children’s 1996 policy on the use of technology by young children. The policy highlighted the importance of developmentally appropriate uses of technology and encouraged teachers to use technology to enhance children’s cognitive and social abilities. In addition, the document advocated integrating technology into the regular learning environment as a means of supporting young children’s learning. There is now significant agreement across the early childhood and primary educational sectors about the appropriate use and application of computer technology. Much of this agreement focuses on the types of software or programming applications that best support the development of children’s problem solving and reasoning skills. However, to date, little research has been conducted on young children’s use of the computer hardware in education settings, including their use of input devices.

The limited research available on young children’s uses of input devices suggests that children can use devices such as touchscreens to complete simple tasks (e.g., moving a cursor) without having to achieve the level of mastery required by other input devices. This was demonstrated by Scaife and Bond (1991), who studied the use of touchscreens by children and adults, finding that there was ‘little developmental change in performance with the device (touchscreen) and [that] the performance of a five-year-old typically was comparable to that of an adult’. While children and adults learned to use the touchscreen at similar rates, the younger children had much more difficulty learning to use a mouse or keyboard than did adults. This finding is likely due to the touchscreen’s more direct relationship between a user’s action and the on-screen effect. Similarly, the mouse has a closer physical relationship between action and effect than the keyboard. This relationship between ease of use by young children and the directness of the input device has been supported by studies that have suggested that the mouse is a more effective input device for young children than the keyboard. However, none of the studies cited above have examined how well children are able to use a touchscreen to complete more complex tasks, such as selecting objects on screen or dragging and dropping icons.

The computer’s accepted status in early childhood education is dependent to a large degree on the reconceptualisation of its potential as a learning tool. To a certain extent, this has depended on the notion of supplying children with developmentally appropriate software or learning experiences that are viewed as being congruent with constructivist approaches to education. However, the limited amount of research conducted into the appropriate use of different input devices for young children would suggest that this reconceptualisation is only partially complete, with an examination of children’s interactions with hardware, or input...
devices possibly suggesting an alternative dimension of appropriate practice. In light of this suggestion the study reported here aimed to explore a series of questions related to the use of a touchscreen as an input device in early childhood and primary educational settings. The research focussed on examining the influence a touchscreen would have on children’s computer use in these settings from the perspective of both the students and teachers. In light of this focus, the following research questions were developed:

• How did the teachers influence young children’s use of the computers and touchscreens?
• Were the touchscreens more useful for particular types of software?
• How did teachers and children perceive the touchscreens?
• Which input devices did children prefer to work with?
• Did the touchscreen facilitate collaborative learning amongst children?

Methodology

The study employed a qualitative framework in order to gather data related to the research questions. The main data collection strategies employed within this framework included semi-structured interviews of the teachers and observations of the children’s interactions with the touchscreen. The observations were conducted across two early childhood educational settings and included five early childhood classrooms as demonstrated in table 1. The teacher interviews were conducted on-site prior to and following completion of the observation period.

Table 1: Study settings and classroom breakdown

<table>
<thead>
<tr>
<th>Setting</th>
<th>Classrooms</th>
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| 1. Independent School, Early Learning Centre | • 1 reception class (three year-olds)  
• 2 pre-preparatory class (four year-olds) |
| 1. Government Primary School      | • 1 preparatory class (five year-olds)  
• 1 grade one class (six year-olds) |

Setting description

The early learning centre associated was associated with independent school and consisted of three separate groups, each comprising approximately 15 children. Each group was in a separate room, which contained a number of activity areas, including a single stand-alone computer. The touchscreen was installed on each of these computers. The preparatory and grade one classrooms were associated with Government Primary school. The preparatory class comprised one teacher and 24 children. This classroom had five Apple computers (including four iMacs). Touchscreens were fitted to three of the iMac computers. The year one class comprised one teacher and 26 children. The year one classroom contained five Apple computers (including four iMacs). Touchscreens were fitted to three of the iMac computers. Altogether five teachers were involved in the study – three from the early learning centre, one from the preparatory class and one from the year one class.
Each of the five classrooms were selected for inclusion in the study for the following reasons:

- The five teachers responsible for the teaching in the selected classrooms had a range experiences in using computers in early childhood education
- The classrooms represented both the independent and government school sectors
- The classrooms included children within the age range (three to seven years) that spans the early childhood period

The physical organisation (classroom layout) of the five classrooms differed between the two settings, reflecting the educational focus of the setting. The physical layout of the early learning centre classrooms was slightly different from the layout of the primary school classrooms. The early learning centre classrooms were organized in order to allow the children to self-select from a range of learning experiences provided by the teacher, and tended to be divided into areas such as block and construction play, literacy activities and dramatic play. The computer was generally located near the literacy activities and constituted a separate play or activity area.

In contrast, the primary classrooms reflected a more focussed organization with tables and chairs placed in relation to the whiteboard and the teachers’ desks. The computers were placed at various points around the room on tables integrated into the children’s everyday working space or desks. Computer use in the primary classroom was therefore more teacher-directed than in the early learning centre where the children were encouraged to self-select learning activities rather than complete computer activities set and directed by the teacher.

**Data Collection**

Four main data collection instruments were employed in order to address the research questions. Due to the exploratory nature of the study it was decided to utilise those instruments that would allow researchers to identify the issues that arose from the children’s use of the touchscreens. In light of this decision, primarily qualitative instruments were used including observation schedules, teacher and researcher journals and semi-structured individual and group interviews. The range of data collection instruments employed increased the researchers’ ability to examine the nature and frequency with which certain issues arose from a range of perspectives. The specifics for each of the four data collection instruments used in the study are as follows:

1. **Observation schedule:** researchers observed each of the five classrooms before the touchscreens were installed using a pre-prepared observation schedule which noted:
   - Features of the children’s learning environment including the layout, organisation and facilities
   - The teacher’s style, approach to the tasks and use of facilities
   - Activities undertaken by children, including their use of computing facilities and interactions with each other

2. **Researcher observational journals:** researchers maintained observational journals during the seven weeks in which the touchscreens were operational. Researchers recorded:
   - Observations of children’s interactions with the touchscreen
   - Comments on children’s behaviour when using the touchscreen
Observations and comments regarding their discussions with teachers.

3. **Teacher observational journals**: teachers maintained observational journals during the seven weeks in which the touchscreens were employed in their classrooms. Teachers were directed by the researchers to record:

- Observations of children’s interactions with the touchscreen
- Reflections/commentary on the observed interactions in light of their knowledge/understanding of the particular children involved in the observation.

4. **Semi-structured interviews**: individual semi-structured interviews were held with each of the five teachers involved in the study prior to the implementation of the touchscreen. At the conclusion of the observational period each teacher was re-interviewed in addition to participating in a semi-structured focus-group discussion. All interviews were audio taped and transcribed.

**Data Analysis**

The data from each of the data collection procedures was collated and analysed by each researcher. Individual researchers identified a series of themes or categories that were recognisable in each form of data collected, including the observational schedule, researcher and teacher observational journals and semi-structured interviews. The most frequently occurring themes identified by individual researchers were noted. These themes formed the basis of a framework that was used to identify the various issues, or main findings, related to the children’s use of the touchscreen.

**Findings**

Five main themes were identified within the data. Each of these themes was found to contain a number of sub-themes or issues that formed the constituted the basis of the main findings. The findings are presented in table 2.

**Table 2: Identified themes and major findings for each theme**

<table>
<thead>
<tr>
<th>Theme</th>
<th>Major findings</th>
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<tbody>
<tr>
<td>Developmental issues</td>
<td>• Children became more familiar and competent with the touchscreens over time</td>
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<tr>
<td></td>
<td>• Children’s responses to the touchscreen were influenced by:</td>
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<td></td>
<td>o How the touchscreens were introduced to the children</td>
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<td></td>
<td>o How children reacted to the teacher’s attempt to support their use of the touchscreen</td>
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<td></td>
<td>o The way in which the touchscreen and the computer were positioned in the classroom</td>
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<tr>
<td></td>
<td>o The extent to which rules of access had been or were being developed</td>
</tr>
<tr>
<td></td>
<td>• Children’s level of motor-skill development influenced the ease with which they could operate the touchscreen</td>
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</table>
Input device preferences
- The type of software being used was a major determinant of children’s preference for a particular input device
- Most children preferred the mouse to the touchscreen

Technical issues
- Touchscreen response speed slower than the mouse
- The touchscreen’s compatibility with other input devices influenced whether or not it was employed by children across all settings

Individual differences
- Touchscreens caused frustration for children who were not competent computer users, whereas more confident users were more likely to see the touchscreen as a challenge
- Boys and girls tended to react to the touchscreen somewhat differently in that boys displayed more competitive and enthusiastic behaviour

Collaboration
- Collaboration was common but often not constructive
- The simultaneous availability of more than one input device increased the amount of negative collaboration

Discussion
The findings suggest that the use of touchscreen technology in early childhood settings is influenced by a range of issues. In the main, these issues are those relating to the children’s developing physical or social skills, or to aspects of the technology itself, such as the speed with which the touchscreen responds to commands. These issues are discussed in greater detail in the following sections, which are presented in relation to the themes identified under the findings.

The developmental use of the touchscreen
The developmental use of the touchscreen refers to the manner in which the children were observed to change their behaviours relating to the touchscreen as an input device over the seven-week observational period. Children were observed to become familiar with the use of the touchscreen over the observational period, however the development of familiarity with the touchscreen appeared to be related to a range of factors. These factors related to how the touchscreen was introduced to the children and its use supported by the teacher; the positioning of the touchscreen and computer in the classroom; the influence of software on the touchscreen’s effectiveness; the children’s levels of motor development, and the extent to which rules governing the use of the touchscreen were developed and enforced by the teacher.
Introducing the touchscreen and supporting its use

The teachers recognised that following the initial introduction of the touchscreen that they would need to support children in developing the skills necessary to operate the input device. Teachers in each of the five settings differed in the way they conducted follow-up episodes and presented opportunities for children to use the touchscreen. In the older classrooms, further group activities (usually with four to six children in a group) were scheduled and the teacher worked with individuals or pairs of children when the need arose. In the early learning settings, the teachers mostly worked with the children singularly or in pairs at the computer. However, across all five settings, the use of the touchscreen was integrated into the normal classroom computer activity. This involved the children working extensively with the computer using various pieces of software throughout the duration of the project. In the older children’s classrooms, the computers were located on the children’s worktables. In two of the early learning settings, the computer was treated as an activity area and placed on low tables within in the classroom for easy access. In the third early learning centre, although the computer was located in the teacher’s office, children were encouraged to come into the office and work on the computer. Peer tutoring was encouraged and flourished in all settings.

Some interesting observations related to teachers’ scaffolding of the children’s experience with the touchscreen and the ways in which teachers managed children’s behaviour while working in groups at the computer. During the course of the project, teachers had to frequently remind some children of the availability of the touchscreen. Some children, for example, were seen to begin using the touchscreen but after a relatively short period of time gave up and either left the computer or returned to using the mouse.

Motor skills

The children in this study were in early childhood and junior primary settings and aged between three and seven years of age. It was noticed that across all of the year levels, children had difficulty in selecting, dragging, and generally moving around the touchscreen using their finger as a pointing device. A similar difficulty was noticed when children tended to use more than one finger and, indeed, their whole hand, when attempting to activate the touchscreen. These difficulties can, at least, be partly attributed to the relative stage of the children’s perceptual-motor development and the development of their fine motor skills. The children’s ability to control the mouse was comparably less affected by this level of skill development. There are at least two possible explanations for this finding. First, the mouse may be a more appropriate input device for children at this stage of their development, especially in where icon size and complexity are an issue. Second, the children are more familiar, and have had more practice, in using the mouse as an input device. Without further investigation it is difficult to determine which of these two explanations is more valid. As more demands are made on children requiring finer motor skills in interacting with complex computer interfaces, the more difficulties they experience. If touchscreens are to be used in early childhood and junior primary settings, teachers and software designers, need to consider both the level of children’s perceptual motor development and the fact that children require a period of time to become competent users of input devices.

Rules governing the use of the touchscreen

It quickly became obvious to all five teachers that the introduction of the touchscreen meant that new rules regarding its use would be required. These new rules tended to develop as the children acquired knowledge and skill in using the touchscreens over time. The grade one teacher expressed a common complaint that, 'Initially the kids liked to use the touchscreen, then they sort of had two or three kids touching the screen at one time so that
caused a bit of a problem.’ One teacher solved this problem by introducing a pairing system in which children were trained to alternate control of the input device. This led to fewer problems with ‘too many hands’. However, even when this strategy was implemented, the enthusiasm of individual children, and the dominance of some children over others, lessened the effectiveness of the strategy. An early learning centre teacher explains the way in which some children by-passed her rules: ‘H sat on the ‘waiting’ chair and constantly gave instructions to O. Also tried to touch the screen during O’s turn … H can be very domineering and likes to control others’ play.’

Both supporting and interfering behaviours were observed in the children’s interaction with the touchscreen. It is clear however, that rules of access to computers, including access to the touchscreen, turn-taking, and controlling the use of input devices, needed to be established. These rules helped to ensure that the children’s behaviour is managed in a collaborative and socialized manner.

Positioning of the computer and touchscreen

The teachers’ personal beliefs about the role of computers in early childhood education influenced the positioning of the computer and touchscreen in the classroom. For example, in one early learning classroom, the computer was placed, often under a cover, on the teacher’s desk in her office, indicating that this teacher did not believe that the computer was a part of the mainstream equipment of the class. Throughout the study this teacher saw the computer as a magnet or major distraction for the children who found it hard to ‘stay away from it’. She saw the computer as a facility to be used with some reservation and with considerable control. Whilst all areas in the classroom, such as the toy corner and the book corner, had rules associated with them, perhaps the most enforced rule observed during the period of the study was two people only at the computer at a time.

Conversely, in another classroom in the same early learning setting, the computer was treated as another activity area and was located on the children’s rather than teacher’s furniture. It was left on for most of the day. In the third room the computer was also located on children’s furniture within the classroom. It was turned on during the free play times, often with the sound being turned down so that it did not disturb other children in the class. It was covered when not in use. In the primary classrooms the computers were also located on children’s furniture within the main teaching area. Hence the location of the computer within the learning environment and, in particular, the ease of access to the children is an important factor in how children interact with the touchscreen over a period of time.

In all the settings, including those in which the computer was appropriately placed to facilitate access, the children had physical difficulties reaching the touchscreen. One of the early learning centre teachers expressed a concern raised by several teachers that ‘reaching up to the screen was a “turn off” for the kids. They are too small to reach’. Teachers using touchscreens need to consider the ergonomic features associated with the traditional placement of the monitor. Lowering and tilting the monitor may well enable easier access for young children.

The influence of software

A significant relationship was found to exist between the software being utilised on the computer and the effectiveness of the touchscreen as an input device. For example, software with simple user interfaces was found to assist children in using the touchscreen since all that was required was a tap on the screen to drive the software. However, more complex software that required the children to drag and drop, make sophisticated selections or use drawing tools was not as effective with the touchscreen. This finding indicates that the
developmentally appropriate use of the touchscreen may be related to ensuring that it is operated in conjunction with software employing simple user interfaces. However, when the children were confronted with relatively complex on-screen tasks, and were given the opportunity to use both the mouse and the touchscreen as input devices, they behaved in ways that were often difficult to predict, often using both the mouse and touchscreen to operate the program. This complexity is illustrated by the following comments from an early learning centre and a grade one teacher respectively:

"O confidently used the touchscreen for the jewel collection and then experimented by touching icons on the main menu screen. When the game changed to pattern making and then marble-counting O switched to using the mouse. H continued to touch the screen. During marble-counting, O changed intermittently between mouse and touchscreen".

"...they are more inclined to use it with things like maths, where there is a shopping one and you have to put bananas or oranges and drag it. And they are inclined to use it more for things with dragging…"

The influence of software is discussed in greater detail in the following section that explains children’s preference’s for one input device over another in terms of the software’s effectiveness when operated by a particular device.

Preference for Input Device

Two main factors were identified as influencing most children’s preference for the mouse over the touchscreen. These factors related to the effectiveness of the relationship between the software user interface and the input device and the children’s prior experience in using the mouse to operate the computer. However, an interesting observation related to input device preference found that some children were able to combine the mouse and touchscreen in order to increase the efficiency with which they were able to operate the computer.

Software interface

As identified earlier, using the touchscreen with software that had a complex user interface was somewhat problematic, and tended to influence on children’s preference for a particular input device over another. All of the software that the teachers were using in the context of this study had been previously developed on the assumption that the mouse and keyboard would be the only input devices used to operate the program. A consequence of this, was that screen icons tended to be small and required accurate navigation of the mouse pointer in order to effectively execute a command. This made the use of the finger as the pointing tool less effective. Some children initially reacted to the inappropriate icon size, and to the computer’s apparent lack of response to their finger touch, by performing multiple touches with their finger. When that failed, they used the rubber tip of a pencil. We assume that this second solution was chosen because the children realised that a finer, more accurate selection device was needed. The ingenuity of this discovery by the children should not be underestimated.

The fact that all of the software used in the project was designed with the mouse and the keyboard in mind led to widespread user difficulties such as inaccurate selections, clicking and dragging problems, and initiating unintended commands. In addition to difficulties caused by relatively small icon size, we noted difficulties due to the placement of icons on the screen and the proximity of icons to each other. Some software appeared to be more suited to the touchscreen than others. Software such as Inside Stories that have large icons
and uncomplicated input requirements were most compatible with the touchscreen. However, software such as Kid Pix and MicroWorlds, with their smaller icons and more complex user interfaces, were less suitable to the touchscreen and caused more difficulties for children. Teachers need to be aware that much of the software currently used in the classroom has been designed with mouse and keyboard in mind. This may well make children’s use of the touchscreen more difficult than it might otherwise be.

**Prior experience with alternative input devices**

Children’s choice of either the mouse or the touchscreen as the preferred input device appeared to have been influenced by their prior experience, familiarity and opportunity for skill development with the mouse. In this study, children at all year levels had already been introduced to the keyboard and mouse and were familiar with using both devices. In addition, many of the children had experience and opportunity to develop skills in using the mouse and keyboard in the home environment. The project commenced in the final term of the school year. By this time, the children at all year levels had become used to using the mouse and keyboard as the primary input devices. Given the fact that the touchscreen was introduced after the children were already demonstrating some proficiency with both the mouse and keyboard, the data was analysed to determine the extent to which their familiarity with these input devices affected their use of the touchscreen. This is illustrated in the following example where the teacher was observed asking one child, ‘Why don’t you want to use your finger? [Referring to the use of the touchscreen] Do you like the mouse better?’ The child responded to this questioning with an emphatic and affirmative nod. Researchers’ observations, teachers’ diary entries and interview comments relating to the three and four year-old classes are littered with similar reference to children’s preferred use of the mouse.

The same preference for the mouse was also clearly evident in the primary school classrooms. However, what was increasingly evident at these higher year levels was that in addition to the order in which input devices were introduced to children, the children’s preference for the mouse was also tied to their more extensive experience with this input device. The prep teacher explained to researchers why she thought that most children reverted to using the mouse:

> I think it’s because they were such accomplished mouse users and when they sit down at their computer, their reaction is to use the mouse and they can do everything using the mouse. I think had it been given to then earlier in the year, I had a few kids who hadn’t been using computers to start with, and I think that would have been very different because if you think they wouldn’t have had any experience with computers, well not to the extent that they have had now, I think that they would have learnt to use the computer using a touchscreen and it would have been very different.

All teachers noted this tendency for the children to return to the input device with which they were more familiar after an initial exploration of the touchscreen. The teacher quoted above speculated that if the touchscreen had been introduced to the children first, then they may have subsequently favoured it over the mouse. This is possibly explainable in terms of interference, where performance on a prior task interferes with subsequent learning (Reed 1994). In all classrooms, the mouse and keyboard had already been introduced to the children prior to the touchscreen. This suggests that their prior learning with the mouse may have interfered with their ability to learn to use the touchscreen, although it should be noted that the level of interference in this situation was different for particular individuals.
Combined input device use

Children often used a combination of input devices simultaneously. This is exemplified in the following discussion with a grade one teacher, in which certain children who are proficient computer users (‘experts’) are shown to be able to use both the touchscreen and mouse in discerning ways.

*Researcher:* …*do you think the touchscreen had novelty value only?*

*Teacher:* Not for the experts. The experts preferred to use the mouse but they knew exactly how to use the touchscreens throughout the whole process.

*Researcher:* So do you think those expert users that knew how to use the mouse, how to use the touchscreen, how to use the keyboard, did they become more discerning users of the three input devices?

*Teacher:* Yeah

The complexity of children’s choice of appropriate input device is also reflected in one of the teachers’ observational journal. In looking at children using the keyboard, mouse and touchscreen in association with Kid Pix software, the grade one teacher noted that:

*Children used touchscreen and also the mouse and were very proud that they could use both. Working through the application wasn’t a problem with the touchscreen. [Two of the children] worked together, one using the touchscreen, one using the mouse. They worked brilliantly together.*

Technical issues

Two technical issues related to the use of the touchscreen by the children were identified. These relate to the response speed of the touchscreen and its level of compatibility with the mouse and keyboard.

Touchscreen response speed

Speed of response refers to the computer’s ability to respond to an input request. Some of the teachers in this project perceived that the touchscreen responded more slowly than the mouse. They believed that this caused the children to become impatient and to use the touchscreen inappropriately. Two observations in particular relate to the perceived speed of response. First, there is a slight difference in the speed of response between the touchscreen and the mouse. Secondly, the teachers’ and the children’s relative inexperience with the touchscreen seems to be a factor in determining how they saw the touchscreen responding to their input. There is clearly a design issue involved in the first observation. Designers need to consider the feedback that the touchscreen provides the user. Differences in response time, as well as other sensory cues, may very well be a barrier to the effective use of the touchscreen in the classroom. The researchers observed that the feedback given to the user by the mouse was preferred over that provided by the touchscreen. This may well be linked to the second observation in that it is the children’s inexperience with the touchscreen and its characteristics that is causing the difficulties.
The physical click of the mouse, like the physical click of the keyboard, seemed to reassure the user that a command had been immediately executed. The absence of a physical click when using the touchscreen left the user in doubt as to whether the desired command had been carried out. This resulted in some children repeatedly tapping the screen in order to get a response. This difficulty may be alleviated by including other cues such as sound effects. We are aware that it is possible to set the touchscreens so the user hears a click when a command is initiated. This feature was not switched on during the project. Further investigation with this feature switched on is needed.

**Compatibility with other input devices**

Conflict between input devices was also a cause of difficulty. There were instances where pairs of children, and individuals, wanted to use both the mouse and the touchscreen at the same time. This tussle between input devices, especially with the IMac’s, often led to machines behaving erratically. It was not unusual, in some sessions, for machines to be rebooted three or four times.

The fact that the touchscreen needs to be calibrated caused some difficulties. At the beginning of the project all touchscreens required calibration. This process set the screen for individual users and determines the fine accuracy of the device. As new users come to the machine, differences in posture, height, finger size and finger movement can have subtle effects on this accuracy. Unlike the mouse, which is independent of children’s individual characteristics, the touchscreen is more sensitive to these differences. Touchscreens need to be more finely tuned to children’s individual differences. To avoid needing to recalibrate the touchscreen for each new user, teachers need to consider the physical set-up of the computer, especially its position relative to the user, so that each user sits in a similar position in relation to the screen.

**Individual Differences**

During the course of the observational period it become increasingly evident that the children’s use of the touchscreen was characterised by their different levels of skill as individual computer operators. There also appeared to be some differences between boys and girls, possibly due to the boys’ observed competitiveness when playing games and their higher level of technical expertise.

**Individual computer competence**

All five teachers were aware of the level of computer competence each child possessed, and would often refer to this when describing individual children’s interactions with the touchscreen. For example, a number of times teachers reported observing children who were not confident computer users as viewing the touchscreen as an additional skill or demand that needed to be acquired. For these children the touchscreen caused increased frustration and they were observed to continue using the mouse, rather than attempting to master the touchscreen, as one of the early childhood teachers noted:

> D was able to use the mouse but was not extremely confident. Once shown the new touch screen she tried this but became easily frustrated when it did not work for her (as she had her palm resting on the screen).

Another child, although not a competent with the mouse, initially tried to use the touchscreen to play a point and click game for the first time. However when this caused frustration, he soon reverted to using the input device with which he was more familiar, as described by the year one teacher:
He pointed to the ostrich (touching the screen). His face showed surprise as the game progressed. He listened to the instructions and touched the appropriate object. Nathan [a competent user] joins him and watches.' On some occasions, these less confident students would use the touchscreen for point and click interactivity and revert to the mouse when they had difficulties, for example in dragging or double-clicking.

Despite this finding, the preparatory class teacher believed that the touchscreen offered potential for reluctant users, describing a girl who had to be coaxed and tutored to use the computer for drawing. This teacher felt that the learning experience could have been improved for this child had she been introduced to computer drawing with the touchscreen rather than with the mouse. Her reasoning being that drawing with the touchscreen was … almost like using a pencil. [The hesitant girl] would have been much better off and wouldn’t have had the trepidation, so I think for the kids that lack a bit of confidence, it would have been a little better.’

The influence of children’s individual levels of computer competence was openly acknowledged in one class, where the teacher had specially designated computer ‘experts’ who were able to work with folders, move files, change printers, and assist other children (interestingly, these ‘experts’ were mainly boys). When the touchscreens were introduced, many of the children who were confirmed ‘experts’ set about extending their expertise to this new piece of hardware. They used the touchscreens extensively, aiming at mastery of a new aspect of the computer. One competent child, for example, ‘appears to really enjoy the option of touching the screen and did not reach for the mouse once during the observation time’, according to the teacher.

When expert users encountered difficulties using the touchscreen, they would revert to the mouse, but tended to go back to trying to master the touchscreen once they had got around the specific problem they encountered. For example, a competent prep child was observed using the touchscreen successfully to play one game, but then had difficulty with another game because he kept inadvertently dropping icons he was dragging across the screen with his finger. He switched to the mouse for a few minutes, and then returned to the touchscreen. For many of these ‘accomplished users of the mouse’, as the teacher referred to them, the touchscreen was a novelty to be explored. Many of these children had computers at home, so the touchscreen presented a new and exciting element in an otherwise familiar tool.

Gender issues

Two aspects of gender appeared to figure significantly in the children’s use of the touchscreen, including competition amongst the boys observed in the study, and the difference in enthusiasm levels between boys and girls. When more than one boy was using the computer, the touchscreen sometimes added to the competitiveness of game-play. Boys would sometimes take turns at selecting answers, or race each other to touch the correct answer, sometimes both using the touchscreen, and sometimes with one using the touchscreen and one using the mouse. A pre-prep teacher observed that, ‘when more than one child is here the boys seem to think that it is a bit of a competition’. This level of competitiveness was not observed between girls or mixed pairs.

A prep teacher noted that in her classroom some of the boys would race each other to use the iMac’s fitted with touchscreens. The boys seemed to be more enthusiastic about the touchscreens than the girls and this enthusiasm was, in some cases, maintained throughout the project. In the Year One classroom, a number of competent boys persevered with using
the touchscreen for most applications whereas the majority of children seemed to prefer the mouse.

Collaboration

Collaboration between children working at the computer and using the touchscreen appeared to be influenced by the teachers’ beliefs regarding the role of collaboration in children’s learning and the children’s level of social development. Overall, the touchscreen tended to promote negative rather than positive collaborations, with the presence of the touchscreen as a allowing children to pursue their individual goals as opposed to encouraging them to cooperate and achieve a common goal via one available input device.

Teacher beliefs

Teachers’ beliefs about the value of using the computer with groups of two or more children were influencing the nature of the interactions taking place between the children as they operated the computers before the introduction of the touchscreen itself. The primary teachers demonstrated an awareness of this in the individual interviews conducted prior to the implementation of the touchscreen. Both primary teachers described the benefits they saw in using the computer in their classrooms, citing increased collaboration and social contact amongst students as an important factor in their decision to have the children operate the computer in pairs or groups.

Prior to introducing the touchscreens, the primary teachers believed that they would increase the ability of groups or pairs of children to interact with a particular program. The observations recorded by the researchers and the teachers indicate that these expected benefits were not overwhelming. Only two positive interactions between children using the touchscreen were reported. One of these was in the primary setting, where the teacher recorded an example of two students employing both the mouse and touchscreen effectively in order to operate a program. The other instance of effective collaboration between children using the touchscreen was recorded by a researcher who noted that ‘R’ and ‘A’ begin taking turns to press the object matching the program directions using the touchscreen’. These observations are contrary the majority of reported interactions between the children.

Researcher observations from both settings recorded many more instances of ‘negative collaboration’ between the children, where the touchscreen is used by children other than the designated ‘operator’ to gain control over the program. In these classrooms, two chairs were placed in front of the monitor. One chair, the observation chair, was intended for the child who was observing but not interacting with the computer. The other chair was used by the child who was in control.

The following example illustrates the manner in which the touchscreen allowed confident users to retain control even when they were supposed to be observing and assisting another less experienced user:

A boy (‘D’) and a girl (‘J’) were working together using The Desert Quest. D was initially the main user and had control of the mouse. He used the touchscreen only once. D was in control of the program and was making all the decisions with very little discussion with his partner. J had very little input and soon lost interest. She made no attempt to touch the screen or keyboard. It came time for the two to swap seats. J now had the mouse and control of the program. D suggested, ‘let use the touchscreen now’ and retained control over the program even though J now had control of the mouse and keyboard.
Before the touchscreens were installed of the teachers predicted that they would be beneficial in promoting collaboration between children at the computer. By the end of the observation period, their opinions had changed and the teachers expressed concern about conflicts between confident and non-confident users, and between boys and girls.

**Social-emotional development**

There were slight differences between the early childhood and primary aged children in the way the touchscreen was used to obtain control over the program. The pre-school children tended to use the touchscreen autonomously to operate the program as they wished, with little regard for the wishes of the other children. The primary children were slightly more aware of the others, changing their language as D did and suggesting 'let's use the touchscreen now' in an attempt at inclusive discussion. This difference is possibly due to developmental differences in the children. This is particularly so for the pre-school children, who developmentally may be considered egocentric in their thinking and social development. This would explain the finding that the two or more pre-school children tended to use the touchscreen at the same time to operate a program, almost in parallel. For example, in the following observation by a researcher, two pre-school children use the touchscreen in order to achieve their own goals with little regard for the aims of the other child.

*D uses the touchscreen to operate the computer from the 'waiting chair'. N continues using the mouse. D touches the screen again and moves the icon to the desired location. N pushing D's hand away shouts 'No!' N touches the screen to move the icon to where he wants it and then uses the mouse to click. D touches the screen. N uses the mouse. N touches the screen to change frames.*

D and N's disagreement as to how the program will be operated appears to have occurred primarily because two input devices are available for their use. In other words, the touchscreen itself is not responsible for the difficulties they experience; the problem may be that the children’s level of social development does not allow them to realise that the other child may posses a different aim to their own. This suggests that the negative interaction occurring between them may be a result of having two input devices available for their use.

The primary children tended to be a little more considerate in their use of the touchscreen than the pre-school children. The older children were more inclined to accept a common goal, and tended to work in tandem to achieve this goal, even when one child used the touchscreen to dominate the actual control of the program. Children in the two age groups used the touchscreen differently, although in both instances such use tended to result in a negative collaboration for at least one of the users. For the pre-school children, the touchscreen simply provided the means for the observing child to operate the program as he wished whilst the operating child continued to attempt operating the program as he desired using the mouse. For the primary aged children, the nature of the collaboration was slightly different in that both children were focussed on completing the same task even though the observer was keen to use the touchscreen to hasten the process when he believed the main user was working too slowly. It would be interesting to note the pattern of behaviour and interactions in both age groups if the touchscreen was the only input device available since the presence of both the mouse and touchscreen might be the cause of those negative collaborations observed rather than the nature of touchscreen itself.
Conclusion

The findings suggest that touchscreens do not significantly assist computer use by young children who have already learned to use a mouse. Touchscreens were used most by the most experienced computer users who sought to master a new piece of hardware, while less experienced users tended to stick to using the input devices they were already familiar with. Children who have not learned to use a mouse may find learning to use a computer easier if they are able to use a more direct input device such as the touchscreen, but such children did not form part of this study.

This study observed teachers' strategies in introducing and facilitating children’s use of the touchscreens, but it became apparent during the study that particular strategies were more effective than others. When introducing touchscreens, teachers need to be aware of children's ergonomic requirements in relation to all input devices, the need for modified rules of computer use, the increased scope for 'negative collaboration', and the need to regularly calibrate the touchscreen. Further research is needed to assess children’s use of touchscreens in classrooms where these successful measures have been implemented.

References