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How pedagogical relations in early years settings are reconfigured by interactive touchscreens

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Abstract

While interactive touchscreens are currently entering into educational practice, little is known about what this means for learning in early childhood and, in particular, how touchscreens shape action and communication. In this paper, we examine the interactions of 2-year-olds and their teachers in a multilingual pre-school in Sweden. We analyse the communicative environment between the children, teachers and shared touchscreens and books in the context of reading. A mixed-methods analysis was used, taking a concept of action that includes both verbal, non-verbal utterances and digital touch. The analysis shows a reconfiguration to the interactional dynamic where children perform comparable amounts of actions in sessions with the touchscreen and book reading but less talk during the touchscreen sessions. However, while talking less, children display other types of communicative actions. We analyse the changing interactional dynamic that follows, its implications to learning and early childhood pedagogical practice and how interaction can be reconceptualised as cycles of communication and action in which educational scaffolding unfolds.

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KEYWORDS

action, affordances, digital touch, early childhood education, embodiment, iPads, language

Practitioner notes

What is already known about this topic

- Touchscreens are a significant part of children's lives and educational curricula.
- There is considerable uncertainty on how touchscreens can be incorporated into early childhood education.
- Little is known about how educational social interaction changes with touchscreens such as iPads.

What this paper adds

- A mixed methods multimodal analysis of the changing actions and dynamics of iPads as compared with bookreading.
- Children's patterns of communication change towards less talk and more bodily communication, while teachers' actions remain somewhat similar.
- Touch actions change the dynamics of interaction, can alter the pedagogical situation and bring a reconceptualisation towards a cyclical and embodied view of interaction.

Implications for practice and/or policy

- New patterns of action may require a recalibration of educational practices.
- Teachers need to attend to new sets of touch actions that children use to communicate and act with as displays of knowledge.
- The use of touch screens should be seen as complementary to established practices of language and literacy training (such as book reading) rather than replacing them.

INTRODUCTION

The everyday presence of touchscreens on tablets and smartphones is shaping how we socialise, communicate and interact with one another (Jewitt et al., 2020). This changing technological landscape influences children's development and learning. National statistics of touchscreens point to a prevalence of this type of technology (Ofcom, 2019; The Swedish Media Council, 2019), which is becoming increasingly common in educational settings such as schools and preschools around the world. However, their use as it enters into childhood educational practices is not well-known, nor how best to integrate them into pedagogical practice. Since 2018 there has been a requirement to educate children toward 'adequate digital skills' in Swedish preschools (The Swedish National Agency for Education, 2019). However, adequate digital skills are underspecified since the area of digital technology is under rapid change: what their introduction to educational settings means is still a matter of dispute and uncertainty.

One such dispute regards long-standing concerns around the potential negative effects of screens on young children's learning and well-being (eg, American Academy of Pediatrics, 2011). Furthermore, its role in educational environments is contested. Digital screen use has been criticised for lacking a social dimension associated with learning outcomes, and is used as a form of childminding apparatus (Lovato & Waxman, 2016). This

concern particularly sits around very young children (under the age of 30 months), where the inability to learn without interaction is well-known (DeLoache et al., 2010). At the same time, there is growing evidence of the learning potentials of interactive and social touch technology (Lovato & Waxman, 2016), as well as for early childhood education (Palaiologou, 2016).

Thus, it is critical to better understand what happens with early childhood educational practices as touchscreens are introduced and better inform their effective educational use. There is now a move toward what Lovato and Waxman (2016) call a 'wider view' of touchscreen technology, which argues for capturing both the educational pitfalls as well as pedagogical potentials of this technological turn.

In this paper, we go beyond the good or bad of technology and turn to examine examples of the changes that are taking place in early childhood education contexts. We examine the in situ interaction of children and teachers when touchscreens are introduced to an early childhood setting and compare these interactions with the well-established practice of shared book reading. In doing so, we aim to examine the communicative environment for the types of actions used by children and teachers. Moreover, we aim to explore the interactional dynamics between children and teachers that may come with the use of touchscreens.

TOUCHSCREENS IN EARLY CHILDHOOD

Educational technology has been an area of considerable research interest. A problem of comparability arises in reviewing evidence for touchscreens as they can have several functions and differ in contexts of use. The rise of so-called educational apps for children has been an area of large industrial effort, and preschool and toddler apps, form the largest category on the iTunes store (Shuler, 2012). The fast pace at which applications are launched has gone beyond what is feasible for researchers to evaluate (Hirsh-Pasek et al., 2015). Considering the substantial amount of time that young children spend with touchscreens per day (Ofcom, 2019; Palaiologou, 2016; The Swedish Media Council, 2019), these issues are of interest across childhood practices.

While from a digital media studies perspective engagement with media is never truly 'passive', within developmental science research on children's 'passive' watching of a digital video shows that it does not aid word learning in the same way as live models, or social interaction (Kuhl et al., 2003; Robb et al., 2009; Troseth et al., 2006). These results are important as they show the educational limitations of leaving children with media. There are simply no gains in verbal language development from passive use of infant-directed media, even in products proclaiming learning such as 'Baby Einstein' and 'Baby Mozart' (DeLoache et al., 2010). These studies point to the limitations of educational quick-fixes that overlook social and educational interaction.

Research on the social uses afforded by touchscreens and how they are employed for learning in early childhood settings (Strouse & Troseth, 2014) is more promising. Roseberry et al. (2014) tested passive conditions of media use compared to live video interaction and video together with adult social interlocutor. Children showed limited word learning from the passive video condition, but learned more vocabulary in both social conditions. Likewise, Eisen and Lillard (2020) showed how children learned more geographical locations from instruction over a real puzzle than they did when using an app replica of the puzzle on their own. However, in a condition when a social interlocutor was present to talk during the episode with the children the digital condition showed similar results on learning as the real puzzle condition. Results such as these point to the role of social contingency as a key to learning (Roseberry et al., 2014), rather than whether it happens on or off-screen. Similarly, Stevens and Takeuchi (2011) refer to the 'joint media engagement' of children and adults to shift focus from the media itself to the social relations where children and adults jointly

engage with digital touch media. This aligns with a Vygotsky (1978) perspective on learning which highlights the importance of communication during shared attention on culturally significant artefacts (Tomasello, 2019). This perspective is common in studies of shared book reading, where teachers and children are interacting around the well-established artefact of the book. One key finding from shared book reading studies is how reading can foster verbal communication and development in the early years (Hindman et al., 2012). Here, the types of conversation that unfolds between teachers and children matter. For example, teachers' use of open-ended questions, instead of simply reading aloud, promotes child language development (Milburn et al., 2014). Research is now turning to the differences between traditional shared book reading and digital-book reading with children. Neumann and Merchant's (2021) study points to ways in which teachers make use of different multimodal components when reading digital books with children. Indeed, Neumann (2020) shows how scaffolding changes in the digital shared book readings, as teachers, used slightly less scaffolding with verbal actions toward scaffolding of technological matters. This points to how social interaction is a key to enabling educational possibilities with the use of technology (Hirsh-Pasek et al., 2015; Roseberry et al., 2014) and the importance of adult-child interaction (Herodotou, 2017). However, how characteristics of interaction are changing in settings with digital tools such as touchscreens is less understood.

The immediacy and usability of touchscreens (Jewitt et al., 2020; Merchant, 2015) also play a role for young children. Scholars in early childhood studies argue that touchscreens can provide ways for young children to express themselves that are conducive to contemporary society (eg, Arnott et al., 2016; Palaiologou, 2016), and reshape interaction (Price et al., 2015). The current study undertakes an in-depth exploration of the role of touchscreens in reshaping interaction and communication in early childhood educational settings.

Vidal-Hall et al. (2020) underline the cruciality of teachers' attitudes when touchscreens are integrated with the early childhood educational practice. However, Hatzigianni and Kalaitzidis' (2018) survey suggests early childhood educators are less confident in the use of touchscreens in preschool than when using it personally. Nevertheless, Wood et al. (2016) observed how parents engaged in emotional scaffolding of children with touchscreens while using a novel application, regardless of the adult's background with technology. The use of language in educational environments might, however, be different as the aim is to educate as well as encourage. There is still much uncertainty of how, when and why touchscreens can be implemented effectively in early childhood education.

Following long-term fieldwork with touch technology, Yelland (2018) argues for it to be seen as complementary to early childhood practices rather than in competition to other activities. These results are promising for the integration of touchscreens into early childhood practices as it 'critically evaluates the affordances of digital tools whilst considering their limitations and relationships with other materials' Cowan (2019, p. 11). Marsh et al. (2018) argue that the specific applications matter and are what influences the early childhood practices the most.

There are, however, considerable gaps in research on the introduction of touchscreens during early childhood. Wood et al. (2016, p. 10) point out that 'future research should consider the relative engagement afforded to mobile technologies versus other important learning opportunities (eg, shared reading)'. Moreover, Lovato and Waxman (2016, p. 1) see a need to examine these 'for infants and very young children, especially research focused on capabilities unique to touch screens'. We agree with this need for foci on touchscreens as they are employed in actual learning settings. The design of this study aimed to address these gaps. In particular, we examine how interactive applications affect the educational encounter, drawing on an explanatory framework from embodied communication and action.

CONCEPTUAL FRAMEWORK: AFFORDANCES, COMMUNICATION AND ACTION

Recent approaches to human cognition and action see human activity as significantly less 'brainbound' than traditional cognitive science (Clark, 2011; Noë, 2009). A major view is that human activity is inherently a coupling of agentive actors with the environment and its affordances. Affordances in this sense are action potentials that range from the physical constraints that environments and objects pose to action (Gibson, 1979) to the social and cultural affordances that emerge in the interaction between people and their world. We promote the importance of semiotic affordances (Kress, 2010), where the set of multimodal possibilities for action are apparent in the current study of books and touchscreens, with affordances that are stemming from the different modes offered by the medium in terms of images, written words and the changing interface offered by the studied interactive applications.

We understand communication in the episodes of shared attention on books and touchscreens to be inherently multimodal, consisting of verbal behaviour, gestural actions such as pointing (Tomasello, 2003), representational gestures (McNeill, 1992), and other bodily actions, such as touch actions on the digital interface. We also see the environment and its affordances as being a part of shaping the interaction between teachers and children. This is in line with an embodied and extended view of thought and action (Clark, 2011; Di Paolo et al., 2018), where for example, a press on a touchscreen can be seen as an action carrying communicative or active potentials, just as a word or gesture may do. Touch can, in this sense, carry not only communicational meaning (eg, Finnegan, 2014) but also actively change the pedagogical environment as children and teachers interact. We find the perspective compelling as a way of understanding not only the verbal and gestural behaviours of children but also as a framework that is conducive to young children's embodied ways of doing (c.f. Thomas et al., 2021).

We take the perspective of McGann et al. (2013) that action potentials unfold in-between embodied, active agents and the environment. This is, however, not always a linear interaction, in that actions might change the environment and thus provide new affordances for the ongoing interaction. We see action here as a process of *dynamical coupling*—we examine actions that might be both communicative and physical in character (such as a press on a touchscreen), that even if not communicative, may alter the interactive pedagogical situation. Thus, pushing or swiping on a screen may not only alter the interactive application but also provide a new state for social interaction and so on. Cyclically, actions thus alter the environment but also push social interaction forward.

The importance of artefacts in these settings is highlighted in the Vygotsky (1978) perspective of the action. For this paper, the joint activity of children and teachers that are interacting with an artefact (touchscreen or book) is the central unit. In this tradition, Tomasello (2003) makes the case that episodes of shared attention between adults and children are pivotal in early learning, where children and adults share intentional actions by communicating with verbal as well as non-verbal means. In this way, communication creates external potentials for scaffolding together with the external artefacts of use (Clark, 2006). Language is, indeed, a key component in this, but in the age group studied embodied action is of fundamental importance. Gestures can convey thought and aid the reasoning of the learner (Goldin-Meadow, 2009) and, being visible in interaction, can provide important cues for teachers to draw on during the pedagogical interaction (Singer & Goldin-Meadow, 2005). We understand gestures and touch actions to be part of the 'cognitive niche' of scaffolding potentials that Clark (2006) describes. We view these cycles of embodied communication and action to the changing set of affordances as critical components of interaction.

We take a broad concept of the communicational environment that is attuned to these perspectives, where actions of teachers and children directed at the touchscreen can also be seen as communicational. Moreover, we argue that actions to the touchscreen may not

only be communicational but also change the artefact as part of these actions. Cycles of communication and action are thus leading the educational interaction forward.

To capture the communicative environment around the artefacts' studied (book or touchscreen), we use an operationalised concept of action which includes all actions that are communicative or actively engage with the artefact, that include not only verbal talk and gesture but also other bodily actions that are directed at the book or touchscreen (see Methods and Appendix).

METHODS

Setting and participants

The study was undertaken at a preschool department in a culturally and linguistically diverse area of Stockholm, Sweden consisting of nine children, two pedagogues and sometimes one assistant. Participants were 2-year-olds (mean age of 28 months). The diversity of the community is reflected in this group, where none of the children shared their first language or spoke Swedish as their main language at home.

In the Swedish preschool system, parents can enroll their children from 12 months of age until they start kindergarten at age 6. The same curriculum is applied for the whole preschool period, with no separation of nurseries and preschools in Sweden. Caretaking and educational activities are purposefully blended in the curriculum, which is rooted in social and playful learning activities (cf. Åström et al., 2020).

Since 2018, the updated curriculum gives digital tools a more accentuated role, stating that preschool children should be educated for digital competencies (The Swedish National Agency for Education, 2019). The preschool understudy has actively been working with digital tools—mainly iPads—trying to make them a more integral part of the intercultural pedagogy (see Samuelsson, 2020). There are two iPads available: one used by the teachers for administrative tasks or planned activities; the other called 'the children's iPad' can be used more freely by the children. iPads are still a relatively new feature: one that, however, is becoming increasingly integrated as teachers use them in planned and spontaneous activities with children, as well as children using the iPads on their own initiative in play.

Data collection

This study is part of a project centred on children's touch and multilingual communication, largely inspired by multimodal ethnography (Flewitt, 2011). Data collection captured the multimodal experiences of children through video recordings, supplemented by field notes and photographs. The fieldwork involved three visits per week, over a month, drawing on Knoblauch's (2005) techniques, aiming to gather dense and rich data in a relatively short period. From our perspective, communication is embodied, with particular emphasis on children's communication that goes beyond the verbal. This requires attention in data collection and analysis to bodily actions, especially the use of hands, given typical movements inherent in touchscreen action spaces and children's use of gesture to convey thought (Goldin-Meadow, 2009; McNeill, 1992).

Sampling and units of analysis

Data comprised around 11 hours of video recording, supplemented by around 250 photographs and field notes from activities. The data was initially coded for a surface-level view

of the activities and behaviours of children and teachers. As the aim of the study was to examine the naturalistic interaction between children, teachers and books or iPads, episodes where these features occurred were selected for further analysis.

The unit of analysis is the episode of shared attention (Tomasello, 2003) between children, teachers and iPad or a book. The communicational space that is represented in the study occurs in the gesture space as conceptualised by McNeill (1992) and Streeck (2009). This is the space in-between and in front of participants, where talk, pointing actions and representational gestures can come together in multimodal human interaction. The analysis aimed to examine the in situ dynamics of interaction with children and teachers using interactive touch technology together and how this may be different from the same type of interactional configuration with books. Episodes were selected where typically two children sit together with an adult and are directed toward the artefact: either reading (a book) or using the iPad with an interactive application. Note that only episodes where interactive iPad applications were used were selected, while sessions mainly showing video without interactive features were excluded from analysis.

From these criteria, comparable episodes were selected—being episodes where teachers and children are sustained in shared attention over the book or iPad—and with teachers and children directed towards the artefact. Episodes with another type of alignment—for example, when a teacher sat in front of children with a book or iPad—were not included; nor were interrupted sessions or sessions when too many actives blended together. This happened, for example, when children played nearby a book reading session and switched between playing and reading activities. Thus, several episodes were deselected from inclusion in the sampling process to maintain comparability in the interactional configuration of children-teacher-artefact.

After the sampling process, a total of 7 shared interactive iPad sessions and 9 shared book reading sessions that fit these criteria were selected for in-depth analysis. These sustained episodes were comparable in length: the shared book readings had a mean length of 5.38 minutes, and the iPad sessions had a mean length of 5.35 minutes.

Analytical procedure

The analysis utilised a mixed methodological approach (Johnson & Onwuegbuzie, 2004) to capture both the frequencies of children's and teachers' actions as well as the relative differences in actions. This approach was employed to capture a broad view of how touchscreens might impact childhood interaction and what this change might entail. Such changes are important to educational discussion and in taking an expanded view of classroom discourse (Lefstein et al., 2015), here taken in the context of early childhood education.

An annotation system in ELAN was created to code each session for the different forms of voluntary behavioural actions from both teachers and children: talk, gestural communication and actions on the iPad, such as presses and swipes. The main rationale for the coding scheme was to apply a notion of *action* in line with an embodied perspective to include verbal and non-verbal communicative action as well as actions on the iPad. The point was not to simply count all types of movement as action but to capture the number of *active engagements* that participants perform. For example, when a participant makes a double or triple press on the screen, we code this as one action (repeated clicking), as our interest is in actions of engaging with artefacts and others, not the number of movements per se. All behavioural codes are listed and described in the Appendix and shown as frequencies in the results section.

After the sessions were coded, a total number of actions could be calculated. We used the broad concept of action from our framework that embraces communicative as well as

bodily actions directed at the iPad. These were collected into the category of actions per minute (APM), which in turn was separated for talk per minute (TPM) and other actions per minute (OPM). This allowed the analysis to show the relative distribution of types of talk to other forms of action such as gestures and touch.

To further understand what these distributions meant for the educational interaction, we turned to analyse the multimodal interaction of teachers and children. Here we examined the qualitative differences between shared reading sessions and iPad use. The analysis used transcription practices inspired by Goodwin's (2000) way of capturing cooperative multimodal action. These entry points allowed an understanding of how verbal and embodied actions (gestured and touch actions) can change the pedagogical interaction and how the calculated frequencies of the action unfold in the actual patterns of interaction.

RESULTS

We begin by reporting the results from the frequency analysis of actions—the total number of actions (APM)—and the distribution of talk (TPM) and other actions (OPM). We then present the types of actions occurring within these distributions, listed according to their frequency of use. We present our interpretation of what this means for interactional dynamics illustrating this through an example of multimodal interaction when children and their teacher use the iPad.

Action patterns of children and teachers

Figure 1 shows APM for the two conditions: iPad and shared book readings. Children's and adult's actions are presented as separate bars. The full bar represents the total number of APM—which consists of TPM (yellow) and OPM (red).

The results show that the total number of actions (APM) children perform during iPad use (8.7) is similar to those during the shared book readings (8.1). However, there are large differences in what types of actions children perform, where the relation of TPM and OPM are almost inverted when comparing actions in iPad versus book reading. During interactive iPad use, children's TPM is 2.1 and OPM is 6.6 whereas, during the book readings, children's TPM is 5.4 and OPM is 2.7. This change in children's action patterns indicates children talking less but performing more other types of bodily communication during iPad sessions.

Teachers do not display this pattern. Teachers perform more APM during the iPad sessions (12.8) than during book readings (9.1). Notably, the patterns of distribution between talk and other actions do not change as they do for children. Teachers' actions follow a similar pattern of mostly verbal actions in both conditions—a TPM of 8.9 during iPad use and 7.2 during reading—which in turn leaves an OPM of 3.9 during iPad use and 1.9 during book readings. This more consistent action pattern is interesting in itself and something we return to in the discussion.

The difference in children's patterns of action is of notable interest. To better understand these changing dynamics, we examine the range and types of actions in more detail.

Frequencies of action types

Tables 1 and 2 show the frequencies of different types of action (the six most common are listed here, more in the supplementary data). Table 1 shows the most common of children's

Actions Per Minute (APM)

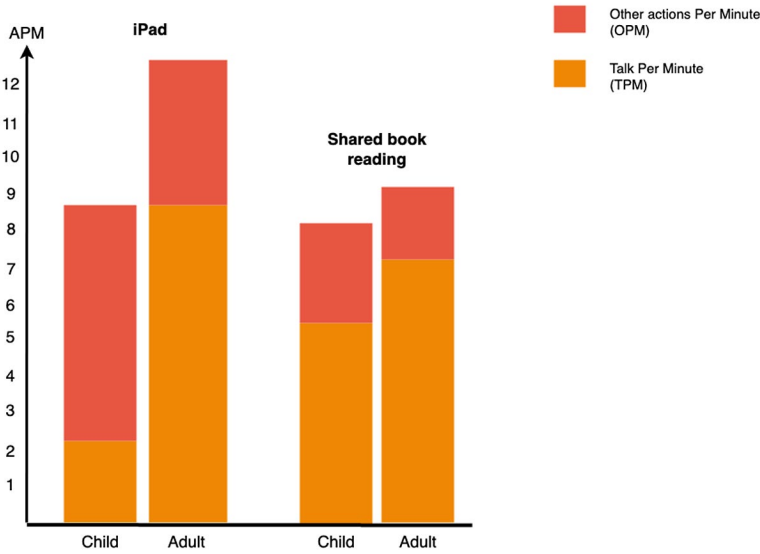


FIGURE 1 Actions per minute (APM), with bars divided into talk per minute (TPM) and other actions per minute (OPM)

actions in both iPad use and book reading, and Table 2 does the same for teachers. As we are concerned with the interaction between children and teachers, the different conditions are discussed separately below to explain how the actions are related and how the interaction under the conditions differs.

Shared book readings sessions

For teachers, there is much similarity between the communicative actions they make with children in both iPad and book reading sessions. Teachers describe things during interaction and often ask questions for children to answer to take the didactical interaction forward:

TABLE 1 Children's most common action types, per minute frequencies

Child			
Most common action types			
iPad condition		Book condition	
<i>tablet press</i>	14.7	<i>talk deictic</i>	7.6
<i>tablet circling</i>	10.7	<i>talk answer</i>	7.5
<i>tablet drag</i>	9.59	<i>talk descriptive</i>	4.4
<i>tablet rep. Clicking</i>	5.5	<i>gesture</i>	3.7
<i>talk deictic</i>	5	<i>pointing</i>	3.4
<i>Point</i>	2.45	<i>knocking</i>	2.7

TABLE 2 Teachers' most common action types, per minute frequencies

Adult			
Most common action types			
iPad condition		Book condition	
<i>talk descriptive</i>	10.9	<i>talk descriptive</i>	8.4
<i>talk question</i>	7.2	<i>pointing</i>	8.3
<i>talk deictic</i>	3.9	<i>talk question</i>	6.4
<i>Point</i>	3.45	<i>reading</i>	5.6
<i>talk request</i>	3.3	<i>talk deictic</i>	4.9
<i>tablet press</i>	2.9	<i>talk answer</i>	2.9

'what is that?', 'is that an x?'. Pointing gestures are more common in book reading sessions. We attribute this to the specific affordances of the books used for this age group—typically board books with illustrated objects to be pointed at and named together with children.

For children in the shared book reading sessions, there are considerable amounts of deictic talk, ie, short references that are rooted in the immediate context, such as 'look! Apple'. Corresponding with the question-category common in the adults' talk, children frequently answer the questions posed to them, eg, 'it's a dog!', displayed in the high frequency of 'talk answer' in the children-book category and correspondingly the 'talk question' type in the teacher-book table. Moreover, we see other types of talk, notably the more elaborate category of descriptive talk, eg, 'the apple is red'. Representational gestures are also commonly used to depict keywords. This is not surprising since this preschool actively promotes a language learning program that trains teachers to use depicting gestures with their talk.

iPad sessions

In contrast to teachers, the children's iPad use carries a considerably different set of action dynamics than book reading. The most common actions—pressing items on the display or circling, dragging and clicking motions—are used to navigate the iPad and utilise the different functions that the interactive applications afford. There is substantially less talk from the children, and it is primarily deictic in character—usually naming things on the display.

One conclusion from these changing dynamics (where children's TPM is lower in the iPad sessions) might be that children communicate less and engage more with the iPad when it is available. However, our interactional analysis suggests that rather than communicating less, the children communicate differently through their touch actions directed at the iPad. For example, children respond to a teacher's question by a touch action on the iPad (example below). There are more actions directed toward the iPad than book reading. While this is in part because of interactive application affordances, it is also because teachers' questions are framed such that they elicit action directed at the iPad. In contrast during book reading, questions are typically 'what is that?', rather than 'what can you do with that?', or even requesting 'push that' as interaction with the interactive application rather promotes. The dialogue, therefore, fosters a more exploratory form of interaction, which inherently enables more child-led interaction.

This hints at some of the crucial qualitative educational differences with interactive iPads. To elaborate on this point and show the significance of these qualitative differences in the educational encounter, we provide a multimodal example of a sequence where this action dynamic is showcased.

Using iPad in interaction

In the following example, a boy and the teacher engage with an interactive application. The boy navigates around a snowy landscape, with interactable items. By pressing or dragging, certain items open up new options within the application. Through navigating the boy finds a large oak tree that seems to catch his interest. He double-clicks the tree to zoom in revealing a door that can be interacted with.

In Figure 2, the boy repeatedly clicks on the door to enter it (1). The teacher then asks, with an engaging voice 'what comes now?'. Through the door, a feature opens that enables children to use a kaleidoscope with different coloured patterns, either on-screen or by creating it live with the iPad's camera. The first option opens, and below the pattern is a bar that can be used to change the colour patterns by moving the kaleidoscope. The boy looks with intrigue before the teacher asks, 'can you follow it' (4). She moves her index finger over the right side of the screen, which could reference several of the possible buttons in the menu bar (4). The boy clicks on an item in the designated area (5)—the kaleidoscope starts transforming again into purple and bright colours—'oh! (.) look at the purple light that came out' (6), states the teacher as the session moves on.

The above example illustrates how interactional dynamics change with the iPad. The application is interactive in the sense that events and possible events change due to the child's and teacher's touch actions. Thus, a question from the teacher typically leads to an action from the child that is directed onto the screen, whereas during a book reading

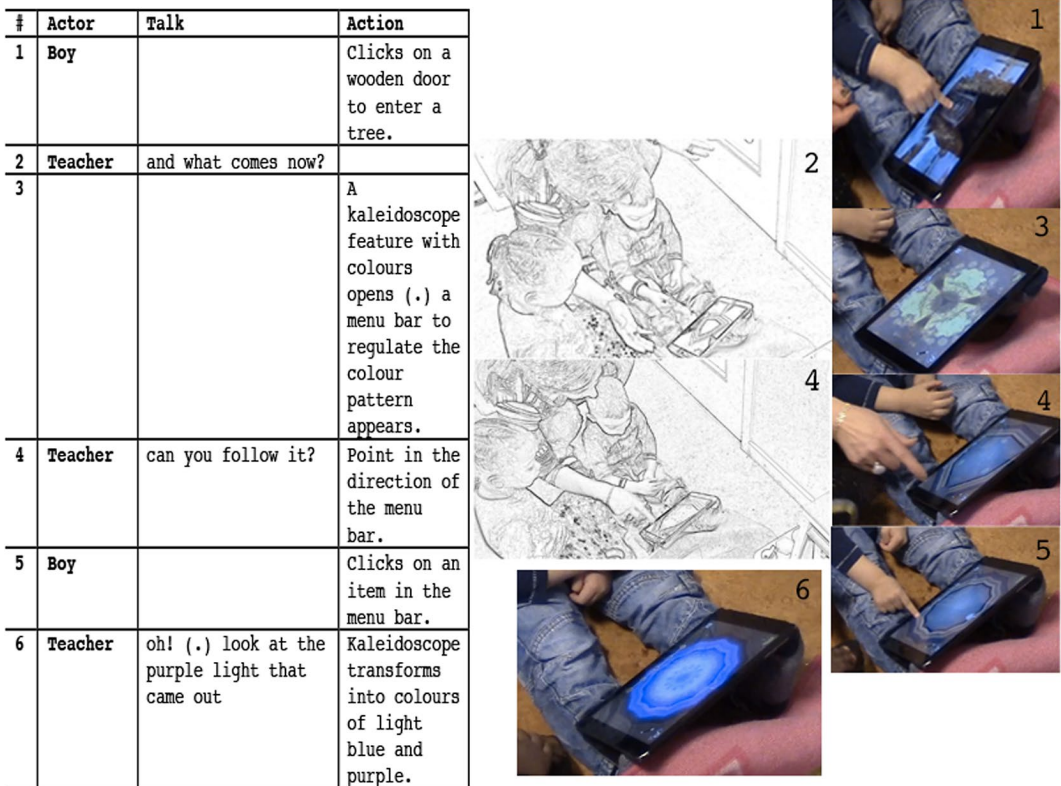


FIGURE 2 Teacher and child are interacting with iPad

session, a teacher's question typically elicits a verbal response. In the iPad context, the child responds to a question not verbally, but through a bodily action that moves the interaction forward through the embodied action (eg, pressing the screen). This changes the dynamics of interaction between children and their teachers. Since actions alter the medium and open new types of interactional possibilities through a new set of functions, the communicative landscape is extended. This changing communicative landscape has important implications for pedagogy and understanding interaction and communication with the iPad.

DISCUSSION

Our findings show that touchscreens change the pedagogical interaction between children and teachers. In particular, that while communication continues to take place throughout the interaction, the mode of communication changes to focus on children's actions on the iPad compared to the more verbally-driven shared book reading interactions. This also provides a different interactional dynamic in the pedagogical process. Here we discuss these results and their educational implications.

Changing patterns of action

The results extend the evidence that points to the role of social facilitation of touchscreen use (Roseberry et al., 2014; Troseth et al., 2006), by identifying how social interaction with the iPad unfolds. We identified children's level of TPM at an average of 2.1 per minute, which is close to the findings identified by Neumann and Merchant (2021) where a child spoke 2.67 words per minute in a study with a similar scenario to ours (the children in our study most commonly speak one-word, and a few two-word sentences). Other studies should examine if this replicates across settings and age groups.

A major result concerns the change in the activity patterns of children, where talk decreases compared to shared book reading but other types of bodily actions increase. This can be attributed to the interactional affordances of the applications, where bodily action both alters the medium and is, in itself, communicative. Using a broad concept of action, which includes embodied actions (gestures and touch) as well as verbal, recognises the need for a multimodal view of communication where each of these can be conceptualised as an utterance (c.f. Tomasello, 2003). This points to the need to include digital touch actions as part of the human communicative repertoire. We note the switch towards increased bodily action for children that is used to both engage with the artefact as well as to communicate in alternative ways. In terms of communication, the gesture space (Streeck, 2009) now includes a set of gestural actions that are specifically directed at touchscreens. Our broad notion of the communicative environment also implicates action in the classroom discourse, and we urge researchers to include this in their constructs, as a part of the ongoing expansion of classroom discourse (c.f. Lefstein et al., 2015).

Notably, teachers' patterns of action do not similarly change. One explanation may be that teachers use similar educational strategies in iPad interaction, as they would with other artefacts (c.f. Tomasello, 2019; Vygotsky, 1978), applying similar communicative resources in other instances of social scaffolding (cf. Wood et al., 2016) as they would during the shared book reading sessions. This can be contrasted with the literature of shared book readings (eg, Milburn et al., 2014) where teachers' questions and verbal interaction are key to enabling children's talk. However, in the iPad sessions, children's patterns of verbal output are changing. We note that teachers' interactional pattern enables children's autonomous engagement with the iPad, which in turn influences the interactional dynamic.

Changing interactional dynamics

Another central result concerns how interaction changes as a consequence of these new action patterns. Following the embodied action framework (Clark, 2011; McGann et al., 2013), we highlight the importance of the coupling during the interaction between participants and the artefacts underuse. We see these instances as *cycles of communication and action*—that is, a dynamical process that also includes the affordances of the external environment. Communication, in this broad sense, can be seen as part of the scaffolding potentials that Clark (2006, 2011) describes as an enhanced cognitive niche, working in tandem with the affordances of the artefact. The children's actions with the iPad are an example of this. When children press something, the affordances change, as well as provide cues for the teacher in terms of new options for scaffolding. This cyclical perspective has implications for how educational interactions are unfolding, where a touch can quite radically change the artefact moment by moment during an interaction.

Implications for learning and education

This study provides important evidence of changes in interaction and communication with young children in early childhood settings with an interactive iPad compared to traditional book reading: one change being that children's talk decreases in the iPad condition, but other bodily actions directed at the iPad increase. While this finding can be seen as a form of creative communicative expression in line with Arnott et al. (2016) observations, it also highlights how this is at the cost of verbal expression. What this means for early childhood education is critical. In an analogous manner of Neumann (2020) where the scaffolding of children changed toward the technological, the same could here be noted regarding children's communication, where more actions are directed at the iPad. The move towards bodily actions by children brings new opportunities for children's autonomy and child-led activity in the pedagogical relationship through the touch action context. However, in the case of our study, the multilingual preschool, the implications are double-edged as they, on the one hand, allow new means of embodied expression and interactive autonomy for the child, but on the other, decrease children's linguistic output in their second language. As with any technology, there are potentials as well as drawbacks (cf. Lovato & Waxman, 2016), highlighting the need for a deeper discussion on what these communicative changes mean for children's lives and learning. We point, with Cowan (2019), to the need for critical concern when implementing touchscreens and how these should be seen as complementary to current practices (cf. Yelland, 2018).

Our other main finding shows the changing interactional dynamic that arises in the iPad condition, where children shape the pedagogical artefacts through their touch actions. Since an action toward the iPad can alter the educational interaction from moment to moment, we propose a perspective of the cyclical interaction of children-adults-environment. This reconceptualisation of educational practice is important, as it speaks to pedagogical environments that increasingly include touchscreens, that alter pedagogical interaction and educational scaffolding. Recognition of what technology brings and how it changes interaction in situ is an important discussion for educators given the negotiation and the ongoing uncertainty of the place of digital technology in early childhood education. Our findings suggest that teachers may benefit from attending to children's actions as communicative acts and be more mindful of children's non-verbal actions (c.f. Goldin-Meadow, 2009). In the context of early childhood, children often enter preschool before they speak. Their non-verbal behaviours are, however, now expanded by an array of digital touch actions that are

intentionally used by children. Work is needed for educational practices to better understand and integrate these affordances of interactive applications and the actions they evoke into a sound pedagogical programme to develop the digital competencies that are promoted in the curriculum.

Across the paper, we have noted the educational implications of interactive applications. Regarding the debate on whether 'educational apps' are educational at all (Hirsh-Pasek et al., 2015), we underscore the need for understanding how applications are integrated into educational relationships between adults and children (c.f. Marsh et al., 2018). We have pointed to how this relationship is being reconfigured with iPads. This educational perspective is somewhat untapped territory for designers and developers of applications, and we urge a closer relationship between hardware and software creators and educational professionals to take advantage of the action dynamics that this study has uncovered. In other words, putting 'education in educational apps' (Hirsh-Pasek et al., 2015), emphasises the need for a deeper understanding of the educational relations between children-adults-technology, and that these relations may need to be reconceptualised in light of new types of actions and dynamics that touchscreens afford.

Limitations and future directions

The study is limited to one preschool and a small number of teachers and children. Further studies are needed to examine if the results hold true beyond the age group of this study (ie, two-year-olds), or if the action dynamics change across children's age and/or among other populations of children. We encourage other researchers to use and discuss the concept of actions that we have developed in this paper to trace communicative changes that seem to be occurring with the advent of touchscreens in educational contexts. Furthermore, future study designs examining touchscreen technologies would benefit from the embodied action perspective presented here—given that the new form of interactional dynamics that is multimodal and includes bodily actions as relevant forms of interaction—since these might not be captured by some theoretical perspectives.

CONCLUSIONS

This paper shows the changing action patterns of children with touchscreen use and how talk is decreasing, and other types of bodily actions are increasingly used instead. This finding has serious implications for education, as the change is not simply towards asocial actions at the touchscreen since bodily actions are often communicative and a strong cue for educational scaffolding. We show that touchscreen actions also change the pedagogical artefact, sometimes altering its functionality. We promote a cyclical view of interaction dynamics, where actions can set a new state of interaction, which allows new functions and new possibilities of scaffolding by an attentive and active teacher.

We have pointed to some significant insights for education and contributed to the work of reconceptualising how pedagogical interactions play out. We urge renewed attention to the various type of touch actions, what they mean, and how they can be used in educationally purposeful ways. There is a new set of interactional possibilities, as well as possible problems associated with these changes, that educational practice needs to consider. The paper contributes to a wider view of how the use of touchscreen technology changes how we live, communicate, interact and learn. Significant work is needed to more fully understand the changing conditions of learning that come with new touchscreen technologies and what this means for education in the future.

ETHICS

The empirical study was conducted in Sweden in regulation with the Swedish Research Council code of conduct regarding information to and consent from participants and parents/caretakers, confidentiality, and ethical use of research data. The standards followed during the research conduct also correspond with BERA ethical guidelines. In the presentation of data, all types of symbols or markers that might entail the preschools, the location, or the identity of children have been removed, and images of children have been masked.

CONFLICT OF INTEREST

There are no conflicts of interest.

DATA AVAILABILITY STATEMENT

Data from the project is available upon reasonable request from the corresponding author. Additional analytical data is available in the supplementary file, as well as upon request to the corresponding author. Annotation files for ELAN are also available upon request and can be openly used by other researchers.

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SUPPORTING INFORMATION

Additional Supporting Information may be found online in the Supporting Information section.

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APPENDIX

LIST OF ACTIONS FROM ELAN

TALK ACTIONS

talk deictic

Shorter forms of descriptive talk, mostly naming of things—eg, ‘that's a horse’, ‘an apple’, etc.

talk descriptive

Talk that is usually a longer sentence than deictic talk and is more descriptive in character. Typically, the descriptions also include adjectives that are not used in the ‘talk deictic’ category, ie, ‘a green pear’

talk question

Questions that are posed by teachers is usually in the typical form of ‘Can you tell me what that is?’, ‘What colour is that?’

talk answer

The answer to a question. This is most commonly a short, deictic answer by the child that is put in this category—‘its red’. While the word or phrase a child uses could, in principle, be

the same as the deictic or descriptive categories, the 'answer' category only indicate that it is the verbal answer to a question.

talk request

a request for someone does something, eg, 'flip the page', 'push that button'.

talk emotion

talk that involves emotional language and sometimes also dramatisation, for example, when enacting characters during a shared book reading—'ooh teddy hurt!'

reading

simply reading the words from the page. As the books read have concise text, the act of reading from one page (usually a short sentence) coded as one action—'the sun rises over Moominvalley'.

OTHER ACTIONS**Gesture**

Gesture here codes for representational gestures meaning both depicting and metaphorical gestures (McNeill, 1992), these are gestures that illustrate or stand in for a word, concept being used to illustrate something abstract with one's hands.

guided touch

Guided touch is the act where, usually the teacher, aid children's hand to move on the touch-screen. This typically happens in the shared sessions with iPads if children need help to perform a movement on the screen.

Point

A canonical pointing gesture, usually with the index finger. This gesture is very commonly used together with the 'talk deictic' category—'look *points* there's the tiger!'.

Phys touch

Physical touch, typically when cheering and hugging after an accomplishment such as reading.

Knocking

Knocking is here used in a unique sense for this context. There is a Swedish board book that is very popular, which involved knocking, and children are advised to knock on doors as pages are turned.

tablet press

a simple touch on the screen is called a press. This movement is almost always done as a precision movement pressing a visible or known function in the application.

tablet rep. Clicking

sometimes a participant repeatedly clicks instead of presses the touchscreen (usually two or three clicks), this is coded as one action 'rep. clicking'

tablet scroll

scrolling on the touch screen is usually done as a short vertical flicking motion, then a release and either another flicking touch or hold, which affords quick scrolling on the iPad

tablet swipe

a swipe is done by either dragging or flicking the screen horizontally. In some applications, the user can navigate or move around with this action.

tablet drag

dragging motion where the finger drags vertically or diagonally on the screen (horizontal dragging is referred to as a swipe)

tablet circling

A circling motion on the touchscreen.

tablet searching

index finger used to glance over the screen, anticipating a press

tablet hold

pressing for a sustained period of time (>3 seconds)