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Children's use of iPads to document their own visible learning

L'uso dell'iPad da parte dei bambini per documentare il proprio apprendimento visibile

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ABSTRACT This ethnographic study explores the use of iPads in the documentation of visible learning by children in a Reggio Emilia-inspired classroom. We report and draw on research conducted with nine- to ten-year olds in a Grade 3 class in the school, situated in Johannesburg, South Africa. "Visible learning" is a key theoretical concept in the Reggio Emilia approach to early childhood education. It envisages a collaborative pedagogy in which children, along with their teachers and parents, document and reflect on their own learning as it happens, thus maximizing its internalization by the children. The study investigates the affordances of iPads in actualizing the documentation of visible learning. The results show that iPads afford young learners with complex ways in which they can document their learning, also ensuring that the technology does not impose itself on them in an artificial manner. The article identifies an emerging language of description of the pedagogical affordances of iPads.

KEYWORDS Affordances; Classroom Ethnography; iPads; Reggio Emilia Schools.

SOMMARIO Questo studio etnografico esplora l'uso degli iPad nella documentazione dell'apprendimento visibile da parte dei bambini di sette anni in una classe ispirata all'approccio di Reggio Emilia. Riportiamo e attingiamo alla ricerca condotta in una terza classe di scuola primaria, con bambini di 9-10 anni, situata a Johannesburg, in Sud Africa. L'"Apprendimento visibile" è un concetto teorico chiave nell'approccio reggiano all'educazione della prima infanzia. Prevede una pedagogia collaborativa in cui i bambini, insieme ai loro insegnanti e genitori, documentano e riflettono sul proprio apprendimento mentre accade, massimizzandone così l'interiorizzazione da parte dei bambini. Lo studio analizza le potenzialità degli iPad per la documentazione dell'apprendimento visibile. I risultati mostrano che gli iPad offrono ai giovani studenti modi complessi per documentare il loro apprendimento, in modo tale che la tecnologia non si imponga artificialmente nel processo. L'articolo identifica un linguaggio emergente per la descrizione delle potenzialità pedagogiche degli iPad.

KEYWORDS Potenzialità; Approccio Etnografico in Classe; iPads; Scuole di Reggio Emilia.

1. Introduction

It is widely believed that information and communication technologies (ICTs) enhance classroom teaching and learning, although what this "enhancement" should be is contested terrain. When it is young children who use technology for learning, the issues become even more contentious. Much of the research on children's classroom learning suggests exciting, educative uses of ICTs. Nonetheless, the literature is generally cautious about the effects of digital technologies on children's cognitive growth, well-being and education (Plowman & McPake, 2013; Gottschalk, 2019). The imperative seems to be avoid hasty generalizations about children, computers and learning, but rather to focus research on classroom and online learning initiatives that suggest significant child development. This study was sparked by the introduction of iPads into a Reggio Emilia-inspired (hereinafter "Reggio") primary school classroom environment.

When we deploy ICTs in a classroom, it is important to bear in mind that "*we should not let the technological tail wag the pedagogical dog*" (Moll, 2012, p.17). In our current context, when the ideology of a "fourth industrial revolution" dominates thinking about education, we have to resist reductionist, *technology-driven* conceptions of digital pedagogy at every turn. The current research problem is how to integrate technologies in such a way that they do not dictate children's pedagogical engagement with knowledge. The imperative is to discover how best to use the often-remarkable affordances of ICTs to enhance classroom pedagogy appropriately. In our research, we find that children's use of iPads in Reggio classrooms allows us to *start* by considering child-specific principles about knowledge and learning, *and then* to question whether ICTs can appropriately enhance such a curriculum. This is the most compelling way to think about ICT affordances for young children in a non-reductionist manner.

2. Background to the study

Networked ICTs influence the everyday lives of children and ramify constantly into education practice. The way young children relate to and use technology is significant. Children these days are deemed "digital natives" or "the Net generation", terms used to describe growing up immersed in digital technology (Prensky, 2001; Tapscott, 1998), vicariously acquiring a pervasive digital consciousness. While the notion of "digital native" has more veracity in developed than in underdeveloped countries (Brown & Czerniewicz, 2010; Czerniewicz & Brown, 2012), research evidence continues to grow that deep seated digital literacies characterize "*the first generation of children growing up in Westernised societies surrounded by increasingly ubiquitous and powerful digital media*" (Flewitt, Messer & Kucirkova, 2015, p.291). Given that the present study took place in South Africa, with the world's most unequal distribution of wealth (World Bank, 2020), and only 58% Internet penetration (Internet World Statistics, 2021), it should be noted that this research was in an elite private school. Its pupils are as digitally connected and literate as any in the richest countries of the world. The study does not purport to make any claims about the more distributed "digital divide" (however one might interpret this) in South African education.

Recently, tablets have become the most popular digital devices in "education markets", with the Apple iPad most prominent amongst them. Upon release in 2010, over 300,000 iPads were sold on day one, and three million within 80 days (Henderson & Yeow, 2012, p.78). In South Africa, iPads accounted for 45% of the market share of 1,4 million tablets sold by June 2013 (Fripp, 2013). By 2013, in the

USA alone, 1.5 million iPads were used in educational institutions (Clark & Luckin, 2013). Today, also in the U.S.A., 99% of teachers use ICTs daily in their classrooms, and 82% of public schools provide each pupil with a computer in all or most grades (Gray & Lewis, 2021, A-1). Almost half of these are iPads (Simba Information, 2017). South Africa shows a similar trend towards iPads, albeit on a smaller scale. Most private schools, and a significant number of public schools, have adopted iPads in classrooms. For example, a roll out of 50 iPads in 50 primary schools per province was planned by 2015 (Tablets for Schools, 2013); South Africa's richest, most populous province justified its "paperless schools" by appealing to the educational prowess of "*digital media such as iPads and other electronic tablets*" (Nkosi, 2014; Falanga, 2015).

In this context, globally and locally in South Africa, the imperative to research the use of iPads in the classrooms of young children is strong.

3. Research aims and significance

The broad aim of this study was to produce an ethnographic "thick description" (Geertz, 1973) of the practices of junior primary pupils using iPads in a Reggio classroom, where *visible learning* is the primary methodology to realize learning outcomes. Then, by analyzing this ethnographic data, to distil a "language of description" of affordances of iPads for young children in their learning, to further understand pedagogical documentation using iPads.

The multimedia "digital documentation" enabled by ICTs offers new possibilities for the recognition, description and appreciation of children's learning (Khoo, Merry & Bennett, 2015; Formosinho & Pascal, 2017; Hooker, 2019). Yet there is little specific, research-based guidance on digital documentation, and a very slim literature on Reggio-inspired contexts (Bath, 2012; Neumann & Neumann, 2014; Cowan, 2019). There is also a dearth of research on the Reggio-inspired digital ethos necessary to facilitate dialogue in digital documentation (Cowan & Flewitt, 2021). This study seeks to make a modest contribution to these identified "research gaps".

3.1. Research question

The core question of the ethnographic study is: "*How do children in this classroom use iPads to document their own thinking?*" The secondary question is: "*What specific affordances of iPads are revealed in the course of these learning activities?*".

The broad expectation - the qualitative hypothesis, as it were - was that iPads add various affordances that bring both breadth and depth to this documentation process by learners. As Erickson (2008) points out, though, the conduct of data collection in an ethnography is progressive problem solving; the study was interpretive in that it assumed the social world of the classroom is continually constructed by children located in meaning-making activities. It sought to understand how children use iPads *meaningfully* to document learning and make it visible.

4. Literature review

The theoretical framework for this study is thus rooted in the principle mentioned earlier, that the integration of ICTs into our teaching and learning practices should commence with an understanding of how a specific pedagogy is structured and how it operates to recontextualize knowledge into the class-

room. The potentials that any ICT has to assist us in that task – that is, its affordances – become the nub of how we decide to use it any classroom. The pedagogy under investigation here, namely the Reggio inspired pedagogical documentation of visible thinking, looks to ICTs for distinctive affordances.

This section has four parts. First, it covers the Reggio educational system. Then it considers affordance theory and moves on to review literature on the affordances of ICTs for young children. Finally, it draws these elements together in consideration of how iPads might afford documentation of children's *visible learning.*

4.1. Reggio Emilia: the documentation of visible learning

The cornerstone of Reggio pedagogy is the *documentation of visible thinking*: children's thinking is made visible through a process of documentation using a range of media, and gathered in a variety of ways, including the children's own representations and observations made by adults. This systematically collected documentation of the children's developing ideas, theories and understandings actively shapes thought as children struggle to represent and reflect upon their ideas. Young children's thinking is seen as a collective process and, through discussion and "provocation", their existing theories and ideas can be reflected on, challenged and modified. (Robson, 2020, pp.98-99)

In the Reggio approach, the learning process builds on children recognizing and representing their own thinking, thus making it visible to themselves, and to their teachers and families in collaboration with them (Childress, 2020; Westerberg & Vandermaas-Peeler, 2021). A favourite metaphor used by Reggio educators is "the hundred languages of the child", connoting the multiple ways that children speak about and represent their experiences of the world.

Loris Malaguzzi (1993; 1994; Malaguzzi & Gandini, 1993) founded the Reggio schooling methodology in the Italian town of Reggio Emilia as part of post–Second World War reconstruction. Malaguzzi was influenced by constructivists like Piaget and Vygotsky (Edwards, 1995; Hewett, 2001; DeVries et al., 2002; New, 2007; Rinaldi 2021), and the progressive educator John Dewey (Dodd-Nufrio, 2011; Lindsay, 2016). From Piaget, he took the idea of the active, thinking, constructing child. Edwards, reviewing Malaguzzi's writings, suggests that the idea of "*cognitive conflict and disequilibrium in powering cognitive growth* […] *was deeply internalized by Malaguzzi*" (1995, p.4). From Vygotsky, Malaguzzi drew the idea that "*children's learning is situated in a socio-cultural context and takes place in interrelationships, requiring the construction of an environment that allows for maximum movement, interdependence, and interaction*" (Dahlberg & Moss, 2006, p.6).

The Reggio approach views children as capable individuals whose thinking must be taken seriously. They are able to research issues presented to them and construct their own understandings in the process. As social beings, they interact with others in constructing knowledge (Childress, 2020). Reggio schooling involves not only teachers and learners, but also parents who assist in providing children with a situated education. The development of children *in situ* is considered the foundation of this approach.

Malaguzzi's core pedagogical principle is that *learning is the consequence of thinking about one's actions on the world* (Ritchhart & Perkins, 2008; Childress, 2020; Rinaldi, 2021). The Reggio curriculum is designed as a series of opportunities for such thinking activity: this reflection by children must necessarily be located in a collective pedagogy of listening, observing and documenting their work (Kashin, 2016; Westerberg & Vandermaas-Peeler, 2021). Reggio values common activity between children, teachers and parents, viewed as "collaborators" in the pedagogical process, in which they develop shared

understandings of any child's learning (Hewett, 2001, p.97; Trepanier-Street & Hong, 2004, p.89; Harju & Åkerblom, 2020). Together they become *protagonisti*, characters in a community of "*gesture, language, mind, emotions, and interests*" (Kennedy, cited in Edwards, 1995, p.6; MacDonald, 2007).

One can see how important *pedagogical documentation* is in the Reggio system. It is "*a visible trace that captures what children did and said* […] *and becomes a tool for continuous reflection while making the learning process visible to teachers, parents, and members of the community*" (MacDonald, 2007, p.232). In principle, it positions the "voice" of the child as the centre of the pedagogical process (Formosinho & Pascal, 2017). Documentation is variously described by Reggio proponents as creating a disposition in the child toward rigorous critical reflection (Ritchhardt et al., 2011; Fernández-Santín & Feliu-Torruella, 2020; Rinaldi 2021).

4.2. Affordance theory

The concept of *affordance* was formulated by the ecological psychologist James Gibson (1977; 1979), to describe the properties of an object that enable a person to use it to carry out an action. More technically, "affordance" refers to action possibilities inherent in objects in the environment. While they are evidently related to the action capabilities of an actor, they are independent of the actor's perceptual abilities, experience, knowledge and cultural practices. Famously, the interpretivist Norman (1988) challenged Gibson, insisting that an affordance was purely a *mental representation*, a perceived possibility of an action, even though such potential may not actually exist in the object. Seemingly intractable theoretical and paradigmatic disputes regarding the use of objects dominated research on affordances for decades (McGrenere & Ho, 2000; Chong & Proctor, 2020).

Volkoff and Strong (2013), however, argue that there is increasingly a "*united front to oppose those who defined affordances as mental representations, arguing that such views directly contradicted Gibson's intention*" (2013, p.819). This emerging realist consensus regards affordances as properties of the environment, albeit "triggered" by actors who realize those affordances. Affordances are no longer widely construed as mental constructions. A number of authors identify the critical realist underpinnings of ecological psychology, and Gibson in particular (Michaels, 2003; Mingers et al., 2013; Jessop, 2015; Bygstad et al., 2016; Niemimaa, 2018), affirming Gibson's original sense that an *affordance* is a property, or a potentiality of an object. It recognizes the "*possibilities of action afforded, or offered by, a given material object or social network*" (Jessop, 2015, p.240). Affordances exist whether or not they are realized, perceived or acted upon by an agent.

The literature also highlights the affordances of social networks. Some authors (Costall, 1995; Kyttä, 2002; Reed, 2013) suggest a latent sociocultural theory in Gibson: other people, and our structured social engagements with them, offer us reciprocal, versatile affordances, such as those in a mother-child relationship:

> *Behavior affords behavior … What the male affords the female is reciprocal to what the female affords the male; what the infant affords the mother is reciprocal to what the mother affords the infant; what the prey affords the predator goes along with what the predator affords the prey; … and so on. The perceiving of these mutual affordances is enormously complex, but it … is just as much based on stimulus information as is the simpler perception of the support that is offered by the ground under one's feet.* (Gibson, 1979, p. 135)

This sociality of affordances (de Carvalho, 2020) is crucial in theorizing learning affordances for young children. Children do not necessarily perceive affordances independently; these are mediated to

them by adults and other children (Costall, 1995). The fact that children do things before they know how to do them, presents a significant challenge to parents and teachers, who must try to perceive affordances through the eyes of a child (Kyttä, 2002; Cordovil et al., 2015).

4.3. The pedagogical affordances of ICTs

A "pedagogical affordance" is not a pedagogy. We pose a threat to young children if we introduce ICTs into the classroom unthinkingly, believing that they bring with them some inherent, new, revolutionary pedagogy. Teachers use the pedagogical affordances of ICTs intuitively and unconsciously – as Gibson suggests all affordances tend to be – to enhance their teaching. ICTs provide affordances for teaching, *not the other way around*, as technocrats sometimes seem to think.

ICTs provide teachers with multiple affordances when they employ ICTs in their classrooms to enable their pupils' work. Battro (2004) describes the bottom-line affordances of computers in learning, such as the selection function of a mouse, a keyboard, a cursor, and buttons on a display monitor. These in turn produce the affordances of pointing, dragging, typing, font sizing, zooming, highlighting, viewing and clicking. There are two levels of affordance here, technological and pedagogical affordances respectively (Drennan & Moll, 2018). Battro's thesis is that the "*global impact of digital technologies on human society, and particularly on education, is related to* […] *the ability to decide to produce a simple change of state in a system" (2004, p.79).* He calls this the *"click option*".

Various authors discuss the affordances of ICTs in relation to complex, depth pedagogies. Laurillard's (2012) *conversational framework* describes the affordances of various media for teaching and learning, without implying that such affordances amount to pedagogies in themselves. The pre-tablet work of Conole and Dyke (2004) examined early online tools and compiled a taxonomy of ICT affordances in education. Drennan and Moll (2018) suggest that seven of these (accessibility; diversity; communication and collaboration; reflection; multimodality and non-linearity; risk, fragility and uncertainty; and immediacy) lie within the domain of classroom pedagogy. Moll et al. (2022) have extended these categories in a typology of the "pedagogical affordances of ICTs". Haßler et al. (2016) similarly claim digitally enabled affordances for teachers using "transformative pedagogical models".

There is a growing literature on ICT affordances in education. This deals mostly with iPads, which Nguyen et al. (2014, p.1) attribute to the "*fast and wide uptake of iPads among the younger generation*". Barreiro (2020, p.92) describes this as the "*child-iPad phenomenon*". Various authors (Valstad & Rydland, 2010; Kuby & Rucker, 2020; Flewitt & Cowan, 2019) point to the iPad's multiple affordances for *researching and learning*, and new possibilities for the representation of knowledge by teachers. Device mobility is a strong theme in this literature. Brand and Kinash (2010, p.147) describe iPads as *"mobile devices … that liberate the learner to realize … anywhere, anytime learning*" (polysynchronous learning). The small size of the iPad affords teacher-student and student-student interactions in multiple learning spaces inside and outside the classroom (Alyahya & Gall, 2012; Drennan & Moll, 2018). Echoing Battro's "click option", Reid and Ostashewski (2011, pp.1689-1690) praise the "*light finger touches (such as taps, swipes, pinch-zooms)*" of the iPad's "*robust textbook-sized screen*", and its display, audio and GPS affordances that constitute an "*information gathering* [and] *media library*".

Research suggests numerous iPad affordances for children's learning. The high level of interaction and spontaneous discussion encouraged by iPads seems to motivate children more than traditional lessons (Cox et al., 2003; Agostini & Di Biase; 2012; Meyer, 2013; Laidlaw & Wong, 2016). Furthermore, iPads enable pupils – even very young ones – more intuitive control of the learning process (Hender-

son & Yeow, 2012; Reed, 2013; Clarke & Abbott, 2016). Maher (2013) ties together different studies to demonstrate how iPads afford multiple learning pathways in the thousands of available iPad apps.

4.4. The affordances of ICTs in pedagogical documentation

There is a growing literature on ICT affordances for children in capturing and sharing learning (Reynolds & Duff, 2016; Rintakorpi, 2016). Formosinho and Pascal (2017) show that digital technology facilitates multimodal communication to integrate the voices of teachers, parents and children in unprecedented ways. Generally, research on e-portfolios demonstrates this capability (Gallagher, 2018; Hooker, 2019), including in the use of iPads (Khoo, Merry & Bennett, 2015).

Trepanier-Street and colleagues (Trepanier-Street, Hong & Bauer, 2001; Hong & Trepanier-Street, 2004), in investigating technology applications in the Reggio curriculum, show that ICTs make documented learning easier – they are cost-effective, save time for teachers and learners, and easily afford sharing children's work with parents. Several forms of multimedia technology can be integrated in the documentation process to enhance reflective thinking. Unfortunately, much of the Trepanier-Street research stops short at technological rather than pedagogical affordances of ICTs.

With regard to specific sources on the pedagogical use of iPads in documenting visible learning in a Reggio classroom, the recent work of Cowan and Flewitt stands out (Cowan, 2019; Flewitt & Cowan, 2019; Cowan & Flewitt, 2021). Beyond this, the literature seems sparse: articles by Mitchell (2007) and Parnell (2012) explore iPad use by teachers to document the visible learning of children in their classrooms. Then there is a handy blog entry by Kashin (2016), useful in conceiving how a digital portfolio, including children's writing and artwork, photographs, audio and video recordings, and computer graphics, can be stored and classified efficiently using iPad technology. The current study makes a small contribution to our knowledge in this area.

5. Research methodology

The study was framed as a small-scale classroom ethnography, in which researchers "visit the classroom intermittently as outsiders" (Erickson, 2010, p.320). The researcher (the first author) positioned herself as a *non-participant observer*, gathering detailed qualitative data in the classrooms of two teachers over a two-month period. She was guided by King (1979), recognizing that children tend to identify an aloof adult in the classroom as an outsider or surrogate teacher. She maintained social distance by showing no obvious interest in them, avoiding eye contact, and mostly sitting at the back of the classroom taking field notes. As Hammersley and Atkinson (1983, p.103) insist, there "*must always remain some part held back, some social and intellectual 'distance'. For it is in the 'space' created by this distance that the analytical work of the ethnographer gets done*".

There is ongoing debate about "backstage culture" of classroom participant observation (DeMunck & Sobo, 1998, p.43) in which bias often creeps in as researchers work with informants similar to themselves, and the latter mislead researchers by reporting what they want them to believe (famously demonstrated by Freeman, 1969, in his critique of Margaret Mead's ethnography). Merriam considers participant observation a potentially "*schizophrenic activity*" (1998, p.103), in the tension between immersion in the setting and the need to keep some distance from participants. However, she suggests, the question is how the researcher accounts for those effects in data collection. In this case, the researcher considered that her familiarity with the participants and with the school's Reggio approach (she taught

the participants a different subject) allowed her to recognise biases. As she positioned herself as observer, she constantly sought to level out biases and maintain an objective stance in the study.

5.1. Participants and location

The primary school in which this study was conducted was purposefully sampled. It is a private, English medium, denominational institution situated in one of the most affluent suburbs in Johannesburg, South Africa. It is amongst the topmost academic schools in the region. The school caters for pupils from diverse cultural backgrounds, who tend to be from affluent families, from early years through to matriculation. The school is known for its innovative curriculum policies and commitment to the pedagogic integration of ICTs. It had adopted a Reggio-inspired curriculum in its junior primary section a decade earlier. Coincidentally, iPads were introduced for each pupil three years later. The school's curriculum imperatives thus required the integration of the pedagogical and technological affordances of iPads into Reggio classroom activities and presented us with the opportunity to carry out this study.

Participants were 54 pupils, 27 in each class, and their teachers. Both teacher participants had recently completed the "Making Thinking Visible" online course offered by Harvard University. Regarding ethics clearance procedures, all participants (along with the children's parents) were invited to be part of the study, and all gave their informed consent / assent to do so. Formal ethics clearance was received from the Ethics Committee of the authors' University. The anonymity of the children is protected here, by using pseudonyms and obscuring their faces in photographs.

The adjacent classrooms are large, bright and airy spaces. Each has the same furnishings, consisting of bulletin boards, lockers, a carpet area, teacher desks, pupils' desks and chairs, smartboards, data projectors, and five networked desktop computers (Figure 1). They lead onto a fenced playground with outdoor furniture, where pupils congregate, and play on a climbing apparatus during their break time.

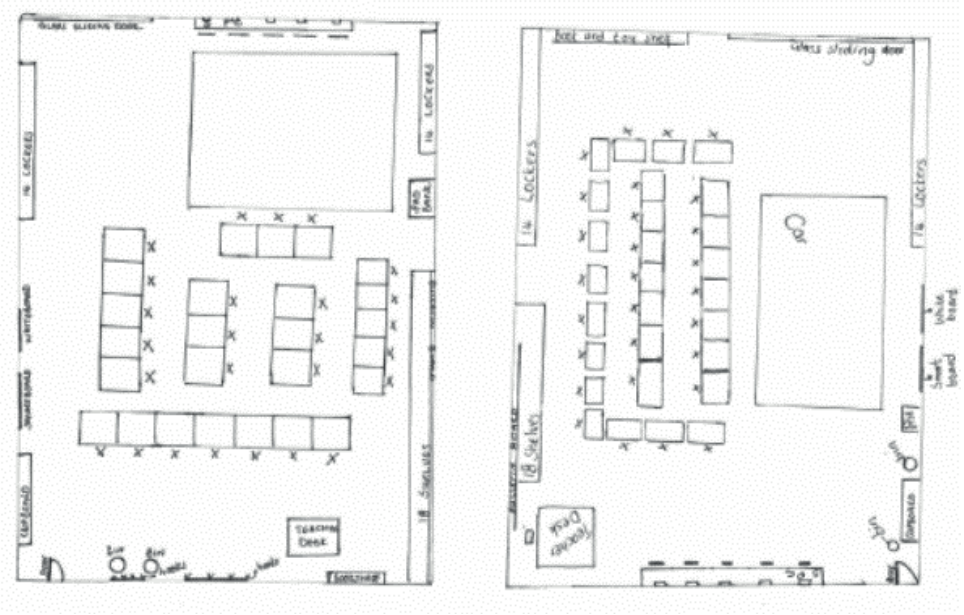

Figure 1. Classroom layouts (researcher field notes).

5.2. Duration and scope of the study

The first author was the sole, consistent observer in both classrooms. She sat in on all lessons in which the theme, "My Heritage", was taught to the two Grade 3 classes over an eight-week period (Table 1) – a total of 64 hours of ethnographic observation time. The teachers formulated the lessons in accordance with national Grade 3 curriculum policies (Republic of South Africa, 2011a; 2011b), and aimed to foster discussion of cultural diversity in the South African context. Prior to this, pupils had engaged in a Special Olympics theme on the "diversity of nations and people".

All lessons were purposefully designed to encourage pupils to make their learning visible using their iPads. Both Grade 3 classes were exposed to the same prepared activities, which included various kinds of online, offline and asynchronous communication events. In a sense, classwork and homework "blended" into each other in ongoing learning processes. The main activity and learning outcome of this eight-week block was the production of an e-book using the multiple affordances of the iPad.

The researcher concentrated on classroom activities, presented and mediated by the teacher, and engaged by pupils by means of and around iPads. She closely observed interactions between learners and learners, and the teacher and learners. When the opportunity arose, she had brief *in situ* discussions with teachers about what they were attempting to teach at any point in time.

5.3. Data gathering instruments

The ethnographic data gathered was textual data. Here "text" is used in its broadest sense. Field notes and children's writing are self-evidently texts, but so too are photographs and artwork. Texts are "*semiotic systems … of meaning, all of which interrelate*" (Halliday & Hasan, 1989, p.5). In this multimodal conception of textuality, visual, verbal and written texts are "read together" as they convey meaning. (Kress & van Leeuwen, 2006; O'Halloran et al., 2019).

The primary data was documentation produced by children themselves, in the form of writing and photographs with their iPads. In addition, the researcher gathered a range of ethnographic data, including children's work, transcripts of recorded classroom conversations, photographs, and field notes. A "thick description" (Geertz, 1973) was produced of ongoing activities in which iPads were used by learners to document their own learning. Such a methodology seeks to "*accurately describe observed social actions, by way of the researcher's understanding and clear description of the context under which the social actions took place*" (Ponterotto, 2006, p.543). It should be noted that learners did not produce work using only iPads, but they documented all of it using various iPad tools and apps.

Table 1. Outline of eight-week course content.

"MY HERITAGE" THEME	
Week 1	Discussion of traditional garments and food
Week 2	Discussion of different cultures
Week 3	Multiculturalism
Week 4-5	Planning the eBook Plan in the Life Skills books Use Popplet
Week 6-8	Creation of the eBook Use Book creator App

5.4. Data analysis

The qualitative method used was thematic, or relational, content analysis (Titscher et al., 2000). Textual data were analyzed by means of standard, cyclical coding procedures (Corbin & Strauss, 1998; Saldaña, 2009). Each cycle revealed patterns in classroom learning. As coding proceeded, we systematically analyzed the entire data set, including documents, observation notes, and classroom transcripts.

In the first cycle, *open coding*, we identified a set of nominal categories, or *codes*, to operationalize the research questions (Titscher et al., 2000, p.59). Words, concepts or significant elements were identified in each text in an inductive analysis involving repeated "sweeps" through the data. This first cycle continued until the data was saturated. The notion of "saturation" is a researcher judgment at a certain point in the coding process that "*no new properties, dimensions, conditions, actions, interactions, or consequences are seen in data*" (Corbin & Strauss, 1998, p.136).

In the second cycle, *axial coding,* we "collapsed" all the open codes into themes (Saldaña, 2009, p.20). We assessed connections and relationships between different elements, and identified patterns of interaction, sequences of events, and meanings understood by the children as they documented their own thinking and learning (see Table 2). The generation of further open and axial codes then proceeded iteratively until concepts emerged to constitute a language to describe the pedagogical affordances of iPads. Here, content analysis was both inductive and deductive. As Erickson (2010) points out, analysing ethnographic data is in principle inductive, but pure inductions are impossible. We strove not to determine *a priori* categories for observation. However, sitting in the background of this study was ongoing work by our colleagues on the pedagogical affordances of ICTs (see, for example, Ndlovu & Moll, 2016; Drennan & Moll, 2018; Moll et al., 2022).

5.5. Validity and reliability

In qualitative ethnographic research, "*reliability and validity are not simply declared by researchers themselves or awarded by reviewers. Rather, they are … built into the process of inquiry*" (Morse, 2018, p.1384). Researchers check the validity (or "trustworthiness") of data to ensure that it is *credible*, *confirmable, dependable* and *transferable* (Lincoln & Guba, 1985, p.300; Morse, 2018, p.1380). To achieve this, we employed multiple data checking strategies.

- *Credibility*: "Triangulation" is achieved by depth of description ("thick description") of multiple layers of observation, data sources and evidence (Plano Clark & Creswell, 2015). In this study, multiple devices and techniques were used to record and triangulate data of different kinds. During the coding process, an academic colleague who was not involved in the research sampled data extracted in the coding process and checked it for coherence and consistency against primary data.
- *Confirmability*: "Member checking" refers to the process where the researcher verifies the accuracy of the empirical observations with study participants (Plano Clark & Creswell, 2015). Regular, weekly debriefings with the participant teachers ("devil's advocates" – Carspecken, 1996, p.141) took place outside of classroom time to corroborate the researcher's interpretations of events.
- *Dependability*: Classroom ethnographers argue that data validity relies on "*repeated visits across substantial strips of time*" (Erickson, 2010, p.323). The researcher must become familiar enough with the classroom setting to be able to assume an *emic*, "insider perspective". However, no formula exists to determine the ideal participation hours. For example, Steele's (2001) ethnography in a mathematics classroom observed learning for a total 30 hours, whereas Smith and Geoffrey's early classic in a US inner-city classroom lasted a full year (Erickson, 2010). This too is a judgment the researcher must

make – depending on the scope of the study and how long it takes them to become immersed in the context. Our judgment in this study was that 64 hours of non-participant observation over eight weeks was appropriate, largely because the researcher (the first author) was a teacher in the school and familiar with the institutional context, although not these particular classrooms.

Regarding *transferability*: since this project was unique in the South African context at the time, we constructed the study simply as general qualitative research. Even "case-to-case implication" (a weak version of the transferability of findings) was not contemplated.

Reliability in qualitative research is not understood separately from validity. The question of the replicability of the results is not of major concern (Lincoln & Guba, 1985, p. 290). The coherence and consistency of data is more important, and the criteria of credibility, confirmability, dependability and transferability also establish reliability. As Lincoln and Guba put it, "*Since there can be no validity without reliability, a demonstration of the former is sufficient to establish the latter*" (1985, p. 316).

6. Results

As we identified emergent categories and themes from the full range of ethnographic data, in the axial coding processes, it became apparent that the children used the affordances of iPads in a number of ways to document their own thinking and learning. The first column in Table 2 records all the open codes (or equivalents) with a frequency greater than five that emerged in first-cycle coding. The second column contains the axial codes, or themes, into which we collapsed the open codes analytically. These indicate the affordances of iPads in documentation to make learning visible.

In each section below, we illustrate these emergent themes by detailing various segments of the "thick descriptions" of classroom activity. We then indicate what inferences about iPad affordances for children we were able to induce from them. Of course, we are not able to cover the full extent of the ethnographic data in this article.

6.1. Motivation and concentration

School learning is characterized by motivated, deliberate attention to the salient features of the task at hand. Piaget calls this "reflecting abstraction", and Vygotsky terms it "voluntary attention" (Piaget,

Table 2. Emergent codes and categories in the analytic process.

Open/first cycle codes	Axial/second cycle categories
Confident, easy, excited, googling, interested, long time, share with friends, stay on task, taking photos, using iPads	Motivation
Attention, focus, google, quick, research, salient feature, selected app, stay on task	Concentration
Active, argument, critical thinking, discuss visible learning, documenting, email, hypothesis, negotiation, reflection, sharing, taking photos	Reflexivity
Anytime-anywhere learning, asynchronous, flexible, free, homework, long battery life, mobile/portable device, movement, outside, seated, sharing, synchronous, tablet size, walking around	Flexible learning
App, colouring-in, data projector, design, drawing, making e-book, pencils, PowerPoint, project-based learning, represent knowledge, software, type of media	Multimodality and multimedia
Discussion, Dropbox, helping, shared focus, sharing resources, sharing skills, just-in-in time peer support, viewing peer work	Participation and collaboration

2001; Vygotsky, 1931, p.99). The outcome of successful school learning, in Reggio terms, is the *internalization* by a child of critical reflection on their visible thinking and learning. Piaget thinks of this as internalization of the consequences of cognitive actions, while Vygotsky emphasizes internalization of the cognitive structure of what is originally a social relationship between a teacher and a learner.

High levels of motivation and attention to task were often evident when pupils worked with iPads. From the classroom observations, when pupils were free to use apps of their choice, they seemed to discuss and experiment easily with potential apps. Pupils were noticeably motivated and fully immersed in their tasks, as evident in Figure 2. Researcher field notes:

Group of kids excited - ask teacher can we use iPads to brainstorm instead of Lifeskills book. Excited when teacher says yes

Sandy, Carly – work quickly, concentrate hard – selecting apps to use [on e-book] – going at it for 15 min!!

On the "dress up day", as part of Heritage Day celebrations, the children enjoyed talking about the various traditional attire they wore (Figure 3), and photographing each other, printing these out, and placing them on the bulletin board. Again, there was recurring evidence of focused, motivated attention to task using iPads.

Researcher field notes:

Take my picture, take my picture, take my picture. …. Lots of kids asking friends to do this

Neo & Abishola discuss how to create new traditional costumes 'to mix up the different cultures' They google on iPad to research in their cultures.

This ease representing ideas on their iPads suggested that pupils took responsibility for tasks, and grew in confidence and independence:

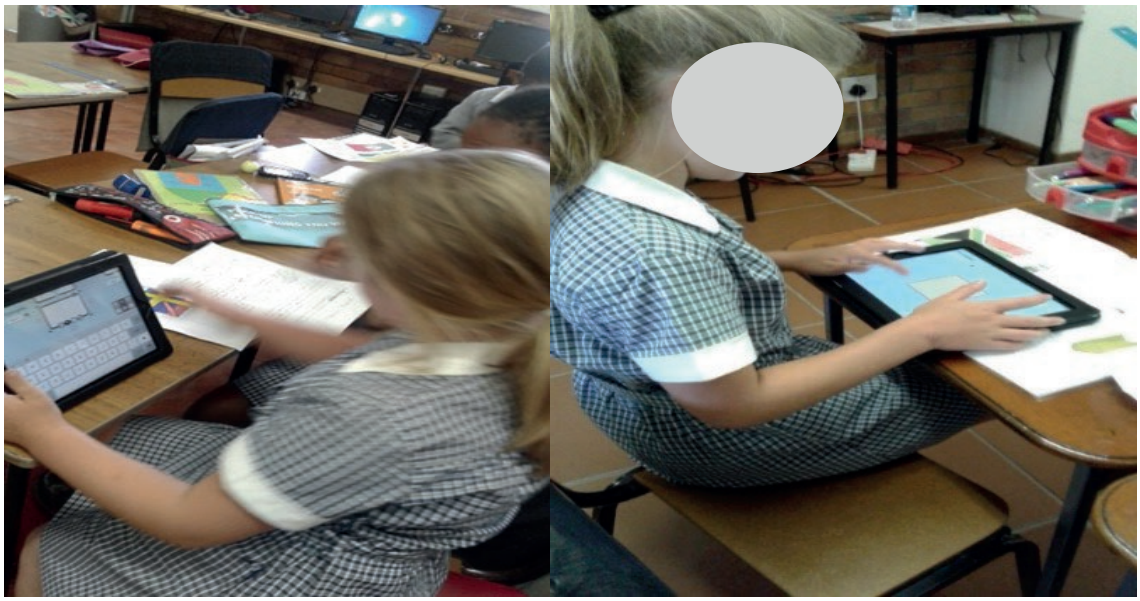

Figure 2. Motivated, staying on task.

Figure 3. Heritage day.

Recorded teacher's comment:

Look how the iPads make them creative, and to use their imagination and to critically think about the tasks they are working on. They are focused and interested. When they document and present their thinking is important because it leads pupils to feeling valued.

There was constant evidence of deliberate decision-making and operational thinking by pupils. While it is difficult for the observer to know what a learner is concentrating on, body language and disposition suggested many examples of prolonged engagement with tasks by learners.

Researcher field notes:

I watch Xoli as she encounters Rasta culture … she noticeably distances herself from kids around her as she concentrates. Facial expression is happy. I am fascinated that she hasn't spoken to anyone for 10 minutes, but downloading and working with images, food, clothing, seems very interested in rastafarian dress… check with teacher: 'yes, this one is very motivated by iPads. Her work is much better now, she likes to work alone' …. end of period, she has not stopped working. But not just random downloading, … CONCENTRATION.
Mindi keeps telling others around her to focus. They recentre around [iPad] *screen.*

From our analysis of the ethnographic evidence, a strong theme that describes learner activity is sustained concentration. We infer that an iPad affords a young child the deliberate focus required to *stay on task* in school learning.

6.2. Reflexivity

The "documentation of visible learning" was the ethos of these classrooms long before this study. It dates back to before iPads, when pupils compiled portfolios of their work. However, iPads have since taken over this function.

Researcher field notes:

Kids keep files- photos & copies of work on iPads. Obviously know how to do it.

Teacher helping a group to make files on iPad to put their documents.

Without exception, pupils took frequent photographs daily of the various kinds of work they produced.

Researcher field notes:

Classroom feels like it is full of photographers. But kids seem to understand they are documenting their work. One asks, 'did you take picture of your poster' 'Duh! Want my mom to see it.

Early on in classroom observations, the researcher noticed children sharing their work with their peers via iPads, *as they did it*. Across the eight weeks, she noticed frequent examples "*all the time, across all lessons*" (field notes).

The data reveal that pupils were inclined to use iPads to document their work. This lends support to the recognition that iPads help learners to think critically about learning tasks (Fernández-Santín & Feliu-Torruella, 2020) – as Krechevsky et al. (2016, p.14) put it, iPads can "*make children's hearts and minds visible to themselves, to their teachers and families*". This perspective on emergent critical thinking in Reggio also arises from the constructivism of Piaget and Vygotsky (DeVries et al., 2002; Stone, 2012). Reggio educators speak of a "spiral of documentation", in which children express ideas and listen to their peers in negotiating their own understandings (Thornton & Brunton, 2015). At the end of each week, the teacher facilitated a whole-class discussion in which pupils revisited their work to consolidate what they had learnt. They plugged their iPads into the data projector to share their documentation and posted their work on the school app for parents to view.

The complex affordances required for the documentation of the cognitive processes in learning are evident from this classroom ethnography. In a Reggio classroom, visible learning evident in these 'documentations' is the centre of the curriculum. Our evidence shows that the iPad provides significant affordances for such *pedagogical documentation*.

6.3. Flexible learning

The project work done by the children does not narrowly confine them to their desks in the classroom during timetabled lesson time:

Recorded teacher comment:

I'm giving them freedom to use any space they want … when they're comfortable in their own space we get better results rather than always telling them where to go.

Figure 4 illustrates this "anywhere, anytime" flexibility in the way pupils worked with their iPads. Some pupils chose to work outside the classroom; some opted to move from their desks while others remained in their seats. The portable iPads allowed them to move around in order to find a comfortable working space. Many engaged in polysynchronous (synchronous and asynchronous) online learning, in and out of timetabled lesson time, at school and at home. In this, they took advantage of iPad connectivity to work after hours (for example on their e-Books), collaborating with their classmates, sharing ideas and images for their projects and tasks.

Figure 4. Flexible work across multiple spaces.

Researcher field notes:

Teacher: 'Olo & Fifi & Mindi communicated abt eBook last night' …. girls show me the WhatsApps.

Teacher: my learners spend much more time than before – hours in fact – working on their projects at home. For this I must thank the iPad.

They are motivated to communicate with each other from home about their work.

Most girls unpack their iPads enthusiastically as soon as they get into class in the morning. Some talk about communication they had the night before.

One interesting illustration of the way iPads break boundaries was the introduction of new dimensions of cultural similarity and difference. Whereas the planned lessons concentrated on food and dress, reflections on differences in greetings (hugs, bows, handshakes, kissing, etc.) and families (nuclear, extended, polygamy, etc.) appeared in the work of some pupils. This obviously originated in iPad knowledge searches.

Analytically speaking, the iPad enables transcendence of the boundedness of the physical classroom. Pedagogy is possible over more extended periods of time, and the 'virtual' extensions of the

classroom made possible by iPads enable and constrain the possibilities for documentation of visible learning in significantly enhanced ways. iPads considerably enhance the teaching and learning methodology that starts in the classroom.

The ethnographic evidence of this study is that the iPad provides significant affordances for flexible and polysynchronous learning. Attributes such as size, long battery life and the touch screen, along with tools for digitalized communication, allow for multiple modalities and methods of learning anywhere, at any time.

6.4. Multimodality and multimedia

The notions of 'multimodality' and 'multimedia' in representing knowledge extend beyond (and predate) ICTs (Halliday & Hasan, 1989; Kress & van Leeuwen, 2006). Good examples of multimedia were produced by pupils without using iPads. Many in fact preferred very familiar paper and pencil (and pencil crayon) technology for certain kinds of tasks (Figure 5). However, the multimodality of the iPad offered these pupils an opportunity to produce complex, creative multimedia documents. They favoured iPads in documenting their visible learning, and shared this digitally with peers, teachers, parents, and all and sundry.

Pupils' presentations were thoughtful and easily focused on the digital screen. As a result of these engagements (in Reggio terms, "*making thinking and learning visible*"), their work on this theme developed in multiple ways, using multiple apps, beyond the introductory engagements in class. Most examples of multiple forms of presentation and representation in the ethnographic data, together provide us with a strong sense of the affordances of iPads in the documentation of visible learning in this classroom.

The iPad has a 'Book Creator' app, enabling learners to design and make their own e-Books. During the period of this study, the children worked in small groups to produce a book depicting cultural diversity amongst themselves, as represented by food. See an example in Figure 6. There was strong evidence that they utilized the multimedia affordances of the iPad in this task.

Researcher field notes:

Figure 5. Multimedia texts produced using technologies other than ICTs.

Mindi takes pics of her drawings to put in e-book.

Lots of them experimenting with colour background for pages – kids moving around and looking at others' work.

Lexi takes pics - iPad's camera – saves them & changes size and layout in eBook.

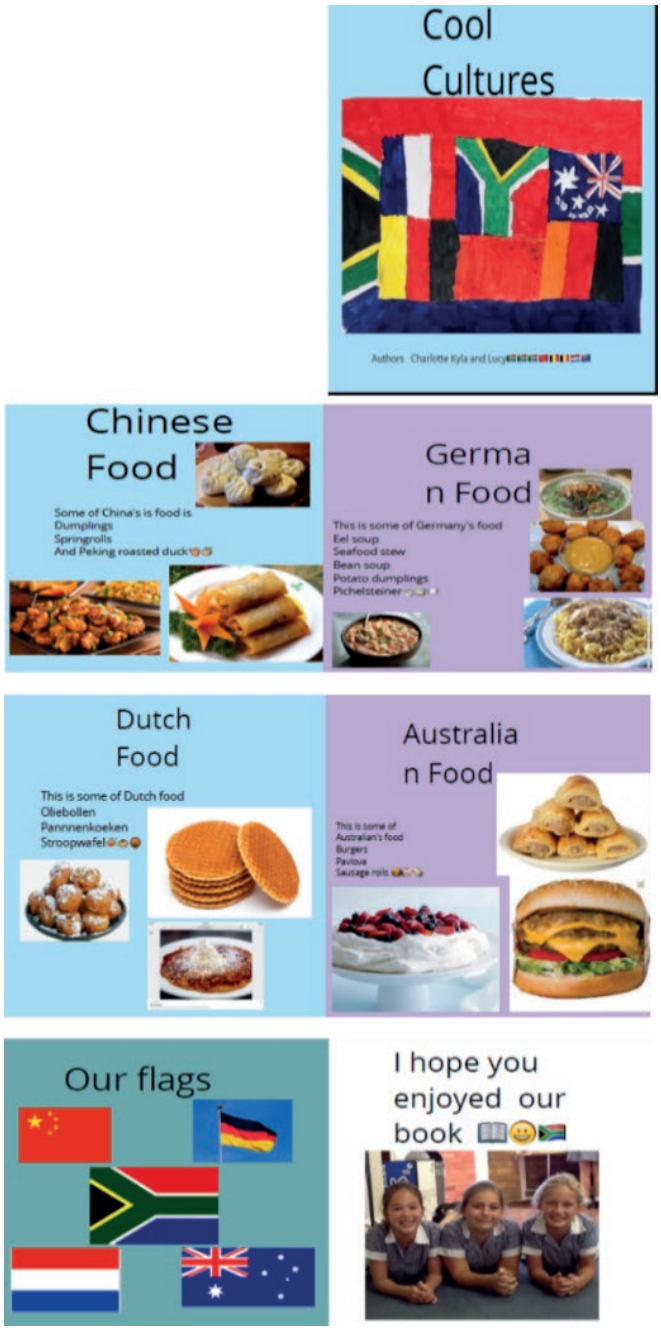

Figure 6. An example of one of the learner-created e-books.

3 girls transfer work from books onto iPads with Camera roll. they say 'easy to organize everything for eBooks.

Pupils used Airserver (screen mirroring software) to present their eBooks to the class. They evidently enjoyed taking the class through their books.

The e-Books seem to make study more project based, which is not just a function of the thematic presentation of content, but an overall affordance of the iPad itself. Instead of just revisiting work done on the iPads and discussing it in a constrained classroom space, it seems to make learning ubiquitous, distributed across their everyday lives. The way that the e-Book project produced reflection by children on their own learning was particularly notable. The researcher reported that they spent long periods of time pouring over their own e-Books, and often modifying them. As most of us do, they went back over their writing intensively during and after the process of producing a text. Many also used the voice-recording feature on the Book Creator app to do voice overs on some pages in their books, and then they revisited and listened to themselves.

There is strong ethnographic evidence here for the Reggio insistence that young children are capable thinkers able to research issues and construct their own understandings of them, and the ability of iPads to facilitate this. It emerges that iPads provide strong affordances for *learner construction of materials*. The multimedia representational affordances of iPads are realized continually in the work produced by pupils in and beyond lessons.

6.5. Participation and collaboration

Pupils generally shared many ideas in the observed lessons, encouraged by the teachers. They questioned and made suggestions to each other, viewing work on each other's iPads. As they did this, they frequently helped each other to use devices and access Internet information. There were a number of instances of pupils initiating learning activities related to a project together.

Researcher field notes:

eBooks - Abishola & Sandy help Daisy find sources on net. Obvious enjoyment finding stuf".

Division of labour – 'you look for this, I'll look for that' then share.

Pupils worked in groups and frequently discussed ideas online about the design of their e-Books. They airdropped graphics to the group's e-Book collator. Importantly, this was not a situation in which children *replaced* ordinary human contact with computer communication channels. Rather, they recruited iPads as tools to enhance normal interactions amongst themselves. This is a good exemplar of what Crook (1994) calls "*collaborative interactions at computers – the design of computers* […] *demands a narrow focusing of attention and action*. […] [their] *powerful graphic capabilities* [support] *shared reference amongst pupils* […] *as they collaborate*" (1994, p.186).

One of the teachers drew the researcher's attention to the way iPad connectivity enables collaboration with parents that is so important in the Reggio approach. Children shared work with parents, using the Dropbox feature, so that they keep in touch in an ongoing way with what their children do in class.

We infer that iPads afford significant *collaboration* and *resource sharing* between children, most commonly amongst themselves, but also with their teachers and parents.

7. Discussion

This article has considered the integration of iPads into teaching and learning in a Reggio Grade 3 classroom and identified emergent themes from coding analyses of classroom ethnographic data. The "thick description" of the practices of young children using iPads to learn and render their learning visible brings a number of the pedagogical affordances of the device into view. Bear in mind the character of an affordance adduced earlier, that it is a property or potentiality of an object that is identified and triggered by social actors. Teachers recognize iPad affordances for teaching as determined by their prevailing instructional practices, but "*these affordances are, ontologically speaking, in the technology, not in the teacher*" (Moll et al., 2022, p.9).

With regard to the first research question of this study, "How do children in this classroom use iPads to document their own thinking?", the discussion above has revealed how the multiple, complex affordances of the device enable and enhance learning. The multiple affordances of the iPad to record work and its products encourage the Reggio "spiral of documentation" and motivate concentration and attention to the salient features of task. Active multimodal representations of knowledge are perhaps the most significant of these affordances. They become ubiquitous in time, space and social context, simply because children are able to carry them around with them and tend to share their screens with each other. Learning is therefore extended beyond the classroom and characterized by much more spontaneous collaboration between learners.

With regard to the second research question, "*What specific affordances of iPads are revealed in the course of these learning activities?*", we suggest that the following technical and pedagogical affordances of iPads in use in this classroom emerge:

- *Polysynchronous learning.* One might say that the portability of devices enables a 'portability' of learning that young children naturally find interesting. Authentic learning at this age is situated culturally and cognitively in and beyond the classroom. The Reggio imperative that children's learning extends into, and is *made visible* in relation to, the broader community context, encourages flexible, ubiquitous learning in young children that is enhanced by iPads. The mobility of learners, inside and outside school, is a crucial aspect of this affordance, arising from attributes such as size, long battery life and touch screen, along with digital communication tools.
- *Deep representations of knowledge*: The Internet in its everyday use is horizontally scaled, with a *broad* information logic; it pops up a plethora of claims, images, speculations and lies that are often difficult to tell apart. It requires the deliberate guidance of a teacher to ensure children use it to realize the vertical, *deep* knowledge logic required in school learning. In Reggio classrooms, the documentation of learning is a very effective teacher strategy to keep learners focused in this way. Children gravitate to their iPads to find interesting affordances to represent new understandings and make their thinking visible.
- *Learner construction of materials:* The creative thinking and ownership of the learning process produced by the e-Book project is self-evident in this study. That children document and reflect deliberately on this learning as well, adds an even deeper dimension to their learning. iPads provide significant affordances for learner construction of materials.
- *Collaboration and resource sharing*: One of the characteristics of the third industrial revolution has been the unprecedented communication and resource sharing possibilities of networked ICTs, not least in collaboration between children, teacher and parent in schools. This Reggio classroom is in fact a fully networked learning community that makes full use of the enhanced digital networks

provided by iPad technology. The study reveals many instances of the collaborative work and community-wide sharing of digitized resources afforded by iPads.

- *Pedagogical documentation*: This affordance is actually an aspect of each of the previously mentioned ones. However, in the Reggio context, the gathering, classification and filing of children's writing and artwork, photographs of their work produced in class, other photographs of their activities, presentations and e-Books, is achieved easily by children using their iPads. Once these pupils were taught the basics of a computer filing system, they managed easily enough. This iPad affordance is much less cumbersome than the paper-based portfolios of old.

As indicated at the outset, the delimitation of this study confines it to a particular, elite, private school in South Africa. It contributes generally to the literature on the affordances of iPads in Reggio-inspired pedagogy and identifies and describes these in a bit more detail. However, the broader question of how such affordances might be recontextualized in the full diversity of schools in South Africa remains an open one in our research programmes (see Moll et al., 2022).

Broadly speaking, the findings of this study suggest a need for more intentional use of the digital environment by teachers to foster and document learning. Perhaps the most important finding, from the point of view of teachers, is the manner in which iPads encourage learners to *focus on task*. Malaguzzi drew from Piaget an understanding that the crucial role of a teacher is "*to create the situations and construct the devices which present useful problems to the child* […] [and] *compel reflection and reconsideration of over hasty solutions*" (Piaget, 1973, p.16); and from Vygotsky the notion that learning is mediated, systematic cooperation between a learners and a teacher, who is thus an active organizer of the frameworks of knowledge of learners (Vygotsky, 1978). The systematic, carefully designed tasks presented by the teacher from lesson to lesson are therefore crucial in establishing what the knowledge and learning focus should be – a matter of pedagogy and not technology. However, what the current study makes clear is that iPads provide teachers with a systematically integrated set of tools (multimedia, apps, Web exploration devices, etc.) that, as they instruct and guide children in their use, afford them the critical reflection and systematic cooperation that encourage them to stay focused on these tasks. It seems that the major recommendation arising from the study is to provide further education and support for teachers in using the pedagogic strategies afforded by iPads (and other tablet technologies) for developmentally appropriate learning.

8. Conclusion

We have shown that iPads afford young learners in a Reggio-inspired classroom complex ways in which they can deepen and document their own learning. In response to the core research question, we have demonstrated how they do this using a particular methodology to record their own visible learning that is well facilitated by iPads. Most notable is the variety and ease of the representation of knowledge that the technology integrated in the iPad affords to both the children and teachers.

We have offered insights related to the flexibility of iPads in enabling collaborative, teacher-mediated learning that is neither time- nor space-bound and emphasizes learner agency in constructing knowledge by producing materials and other artifacts. iPads not only enhance prevailing mainstream classroom teaching and learning, they also motivate children to extend this beyond the confines of the classroom, as iPads link them in unprecedented ways.

At a theoretical level, the study suggests that iPad affordances add a range of previously unrealized representational and learning possibilities into an early primary classroom, but not in such a way as

to undermine prevailing pedagogies and learning approaches. There is consistent evidence in this case study of a specific school that Reggio pedagogical principles are the foundation of curriculum delivery, and iPad affordances are mobilized to the extent that they enhance and enable the realization of these principles. The study suggests how we might avoid the technocratic destruction of teaching and learning cultures that ICTs often bring with them.

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