
Point and Click: theoretical and phenomenological reflections on the digitization of early childhood education

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ABSTRACT This article presents some theoretical-methodological reflections on the current state of the art of research on information and communication technology (ICT) in early childhood education. The implementation of ICT in preschool has triggered considerable research activity on the educational potential of digital technologies. Numerous projects and studies are being carried out in several disciplines; however, there is little or no interdisciplinary exchange. In this article, the author presents and justifies a theoretical-methodological alternative – namely, piecemeal theorizing. Piecemeal theorizing consists in posing precisely formulated questions at different levels of generality, the pursuit of which will necessarily lead the researcher(s) in several disciplinary directions. The author suggests a mode of research conducted by multidisciplinary and piecemeal theorizing of precisely defined and demarcated questions at different levels of granularity, hence accumulating partial answers resulting in theory development and scientific progress – however incremental – in the field. By drawing on theories and perspectives from fields such as cognitive neuroscience, media psychology and phenomenology, we might be in a position to better address some fundamental and largely unaddressed questions pertaining to the potential impact of digital technology on children’s learning. Specifically, the article focuses on one such question – namely, the particular *intangibility* of the digital – and reflects on the potential implications of this intangibility for learning and literacy development. The aim is thence to provide an alternative conceptual, theoretical and epistemological framework for studying the experiential impact of digital technology on preschoolers’ literacy development.

Introduction: digital technology and preschool children’s literacy development

The ongoing, large-scale implementation of information and communication technology (ICT) in preschool has triggered considerable research activity across disciplinary boundaries. An attempt at subsuming the diversity of approaches under a common objective labelled ‘ICT in early childhood education’ leaves the impression of a field akin to the Tower of Babel: there is a plethora of tongues, but little or no substantial communication. Such a lack of communication is particularly evident between fields such as, on the one hand, experimental and cognitive psychology and neuroscience, and, on the other, qualitatively oriented schools of literacy and early childhood education. Research findings from arguably pertinent fields such as media psychology, neuroscience and psychobiology all seem strangely alienated from the field of digital literacy in general, and from studies on ICT in preschool learning and literacy in particular. Moreover, as noted by several researchers (see, for example, Plowman & Stephen, 2002, 2005; Warschauer, 2006; Buckingham, 2007), the field is polarized beyond rationality. Regrettably, much of the discourse falls prey to a simplistic and scientifically counterproductive situation of proponents and opponents

of digital media, in which accusations of neo-Luddism/technophobia or technophilia tend to overshadow important questions pertaining to the role of ICT in children's development.

In what follows, I will outline an alternative approach to studying the educational potential of ICT in preschool – namely, piecemeal theorizing. Originally proposed by philosopher Noël Carroll (2003) as a response to the theoretical-methodological development in film studies, piecemeal, bottom-up theorizing consists in posing precisely formulated questions at different levels of generality, the pursuit of which will necessarily lead the researcher(s) in several disciplinary directions. In my view, many fundamental questions pertaining to the educational potential of ICT in early childhood education remain unaddressed. Among these, questions concerning the potential impact of *the intangibility of the digital* present themselves as particularly urgent and, at the same time, curiously overlooked. When interacting with the typical desktop (or laptop) computer, the user does not have direct, immediate contact with the objects being manipulated on-screen. The spatio-temporal contiguity between action (for example, clicking with a mouse; tapping keys on a keyboard) and perception (audio-visual effects of the input, presented on a screen) when manipulating physical objects in real life is interrupted in digital environments. What may be the implications of this experiential and attentional detachment of the sensorimotor input and the (audio-)visual output? In order to adequately address such questions, we would arguably benefit from readjusting our theoretical-methodological scope in the direction of more fine-grained approaches dealing with material and technical properties of the technologies and software in question, and how these configurations might be more or less supportive of different aspects of preschool children's literacy development. We still lack fundamental understanding of the complex cognitive and sensorimotor processes underlying children's interaction with digital technology in all its manifestations. For the purpose of addressing this topic, I suggest a mode of research conducted by multidisciplinary and piecemeal theorizing of precisely defined and demarcated questions at different levels of granularity, hence accumulating partial answers resulting in theory development and scientific progress – however incremental – in the field.

A Theoretical-Methodological Reassessment of the Field

In my view, studies of the impact of ICT – for instance, interactive toy technologies or educational computer games – on children's learning and literacy development warrant insights into the perceptual, cognitive, sensorimotor and phenomenological nature of the human mind/body. Hence, applying a piecemeal approach drawing on research from adjacent fields – such as cognitive neuroscience, psychological theories of attention and perception, and phenomenological accounts of subjective experience – seems to me as relevant as the predominantly top-down, sociocultural approaches to a large extent dominating the field. Overly sociocultural approaches tend to ignore, or at least downplay, crucial common factors of our phenomenological, psychosomatic experience, reducing them to a consequence of external social or cultural factors. Obviously, we are always situated in, and shaped by, social and cultural contexts and histories. However, we are also phenomenological, embodied human beings of particular biological, cognitive and sensorimotor configurations, sensing and interacting with artefacts and technologies in our lifeworld. These artefacts and technologies present a variety of technical and material affordances [1] which always, in different ways and to different degrees, impact our sensorimotor, cognitive and phenomenological experience of whatever we engage with. Further, and particularly important for the present purpose, these affordances vary in the ways and extent to which they might support, or in other cases potentially impede, learning. Hence, assessing the educational potential of various implementations of ICT warrants a thorough knowledge of technical and material affordances of different technologies, and how these interact with the combination of sensorimotor, perceptual and cognitive dispositions in the user. To what extent and in what ways are the theoretical-methodological paradigms currently employed in studies of ICT in early childhood education addressing these aspects?

Many of the currently prevalent research perspectives in the field of literacy studies – in preschool and beyond – can plausibly be described as explications and interpretations of the sociocultural aspects informing and shaping both the materiality and the social contexts of these technologies and their representations (see, for example, Gee, 2003; Yelland, 2005; Säljö, 2006;

Barton, 2007; Buckingham, 2007; Ito et al, 2010). As a corollary, research findings often end up at a remove from the physical, sensory, perceptual, cognitive and affective experience of the technological and material platform and interface of the medium. In a recent contribution to the field of research on children and new media, Ito et al (2010, p. 197) argue: 'There is still little work looking at how different genres of games intersect with different types of game play and broader structural conditions such as gender, age, and class identity'.[2] The authors aim to fill some of these gaps in the research literature by presenting 'gaming in context' as their conceptual framework. Such a framework implies 'positioning game play within a *broader ecology of media practices and identities*' (Ito et al, 2010, p. 197; my emphasis). While underscoring the relevance of the media content (for example, the 'text'/representation) in question, the authors maintain that 'it is just one among a series of players in the ecological dance that results in complex social, cultural, and technical outcomes' (Ito et al, 2010, p. 200). Evidently, research focusing on the broader social and cultural ecology contextualizing game practice certainly adds indispensable knowledge to the field. However, in disagreement with Ito et al's (2010) assertion, I will claim that the field is largely dominated by these contextual approaches, to such an extent that research on the interrelationships between material and content-focusing aspects of the technologies and software on the one hand, and the sensorimotor, perceptual and cognitive make-up of the player on the other, ends up being essentially marginalized and unfortunately neglected.

For the sake of advancing research in the field of ICT in early childhood education above and beyond what could turn into a theoretical-methodological impasse, I will argue in favour of turning our attention from 'the encultured body', as film theorist Vivian Sobchack (2004, p. 3) describes it, to 'embodiment' – in other words, to 'a radically material condition of the human being that necessarily entails both the body and consciousness, objectivity and subjectivity, in an irreducible ensemble'. A turn from outwardly oriented, context-focusing sociocultural perspectives to approaches addressing the complex and multifaceted interrelationships between the sensorimotor dispositions and cognitive architecture of the individual, phenomenological human being with his/her environment presents, in my view, a scientifically sensible and constructive focus which merits more than its current marginal place in the field.

Such a theoretical-methodological reassessment in the direction of the interplay of sensory modalities, material and technical affordances, phenomenological experience and potential impact on literacy development necessarily entails downsizing the attention paid to social, cultural, historical, ideological, political and gender-, ethnicity- or class-related contexts that can all be claimed to be a part of the – enormous and multifaceted – problem complex 'ICT and early childhood education'. Obviously, this is not to say that we do not interact with media and technologies in social and cultural settings, or that the historical backdrop of media, literacy or human–technology relations is a priori irrelevant. However, there ought to be – *important* – questions pertaining to the issues of children, learning and ICT, in which contextual aspects such as these neither require nor merit centre stage. Examples of such questions could be the ones pertaining to our psychological, sensorimotor and phenomenological relations to technological interfaces, and the impact these have on children's reading and literacy development.

Digital technologies challenge the user into new physical, ergonomic, perceptual and cognitive positions and actions, requiring and generating complex processes of interaction. Two features of these digital technologies present themselves as particularly distinct (and, at the same time, curiously unnoticed in the research literature) – namely, the aspect of the *materiality* (or physicality – the tangibility of the physical versus the intangibility of digital displays) of the technological platform and the *multisensory* nature of the interaction. Any theorist trying to come to terms with the impact of digital media on children's experience, then, would arguably merit from drawing upon theories thoroughly focusing on media materiality and on perceptual, sensorimotor, cognitive and experiential faculties of the embodied mind during play. Although these aspects have received scant attention from theorists in the field, the process and experience of interacting with digital technology engenders, I argue, as much of a bodily perceptual as a sociocultural dimension. More importantly, research findings from adjacent disciplines might shed crucial light on the experiential relationship between these bodily perceptual features and different technological interfaces. In order to make scientific progress in the field, continued failure to

adequately address these aspects might leave us with some conspicuous shortcomings, particularly when considering recent and current breakthroughs in disciplines such as cognitive neuroscience.

A multidisciplinary, piecemeal, bottom-up approach drawing upon adjacent scientific disciplines such as cognitive neuroscience, cognitive and behavioural psychology, phenomenology and media theory would, arguably, be able to at least partly account for the inherently *multisensory* nature of children's interactions with any technology, whether it is paper, crayons and scissors, the felt board, wooden building blocks, electronic storybooks, or the computer. We do not yet have – and will never have – one grand theory, or even a set of theories, adequately and comprehensively accounting for the impact of ICT on children's reading and literacy development. What we have is an increasing number of unanswered questions, the piecemeal pursuit of which necessarily implies and elicits truly multidisciplinary endeavours. Typically, technological development advances and innovative platforms are being introduced at ever greater frequencies, with the research on these technologies and how they impact our reading, learning and cognition lagging behind. However, making the nature of the human sensorium our starting point, we will be in a position to better formulate, address and at least partially answer question complexes of a long-term nature pertaining to fundamental relationships between humans, technology and learning.

A cursory glance at the current and recent research literature on the use of ICT in preschool reveals a field in dire need of more substantial, in-depth theorizing. Lydia Plowman & Christine Stephen (2003) refer to the proliferation of reports, articles and websites making unsupported claims about the potential benefits of digital technology for children. Many of these articles, they claim, present '*generalized discussions of the potential benefits*, followed by cautions to use developmentally appropriate software and some of the claims rely on assertion rather than empirical study' (Plowman & Stephen, 2003, p. 150; my emphasis). In another research article, Plowman & Stephen conclude:

Although there are exceptions, we know very little about the ways in which children react to and interact with the technology available in the playroom. Our observations suggested that computer play does not always act as a support for learning. We found examples of software that informed children that their answers were incorrect without explaining why and other games that gave the correct response after repeated incorrect answers but did nothing to draw a child's attention to why this was the correct response. This is unlikely to support learning. (Plowman & Stephen, 2005, p. 153)

By implication, if we are to contribute to a comprehensive understanding of how digital technologies – such as computer games or interactive toys – might impact learning, in more and less constructive ways, we would greatly benefit from combining diligent analyses of the content and the technical and semiotic affordances of these implementations, with equally thorough analyses of perceptual, cognitive and sensorimotor processes at play during the interaction.

From Defining Learning as Socioculturally Situated to Studying Cognition as Sensorimotorially and Phenomenologically Embodied

Traditionally, fields such as neuroscience, ecological psychology, cognitivism, phenomenology and the philosophy of mind have not been considered particularly close allies. A recent epistemological trend, however, has revealed that there are important and intriguing commonalities and complementarities between these orientations of science and philosophy – commonalities which, moreover, hold considerable explanatory potential for the fields of education and learning – in preschool and beyond.

Typically, in studies on the educational potential of (digital) technologies, the role of the materiality – for example, the technical and material affordances – of the device is rarely addressed: What difference does it make for the reading experience that children point and click with the computer mouse, and scroll and navigate through ephemeral interactive hypertexts on screens rather than flipping and browsing through pages of a bound book, and pointing at pictures on unyielding printed pages? How might the skill of writing be impacted by the fact that they press keys on a computer keyboard rather than laboriously form the letters by hand (Mangen & Velay, 2010)? What might be the short- and long-term cognitive and educational implications of increasingly replacing sensorimotor interaction with physical objects with vision 'as the primary

arbiter of reality' (Wilson, 1998, p. 30), as virtual representations increasingly replace real-life experience?

The emerging cross-disciplinary paradigm of 'embodied cognition' seems to me particularly relevant in order to address such questions. Embodied cognition denotes a recent theoretical trend in psychology, biology, neuroscience, phenomenology and the philosophy of mind, focusing on how perception, cognition and motor action are closely connected and reciprocally dependent, and how they interact with and shape cognitive processes at different levels (see, for example, Clark, 1997, 2008; O'Regan & Noë, 2001; Wilson, 2002; Noë, 2004; Thompson, 2007; Jensenius, 2008). According to this perspective, perception is an active, multisensory probing of the surrounding lifeworld; hence, the paradigm has analogies with the ecological psychology of J.J. Gibson (1979), in particular his concept of 'affordances'. Affordances are meaningful and persistent properties of the environment which are perceived by an organism (for example, human and animal) as opportunities for action (Gibson, 1979; Reed, 1988; Allen et al, 2004). According to this view, we attend to the opportunities for action implied by these objects, rather than to the physical properties of objects in the environment per se. In other words, we see the world as we can exploit, explore and use it, rather than as it is (Gibson, 1979).

A central and far-reaching implication of these strands of thought, particularly relevant for the aspect of intangibility, is that learning and cognitive development are about developing representations about how to physically interact with the environment – for example, about how to explore our surroundings by means of all our sensory modalities, rather than about making internal representations – a quasi-visual 'snapshot' of the environment itself. Thus, learning and cognition are inextricably tied to and dependent upon our audio-visual, tactile, haptic [3] *probing* of our surroundings. In other words, it is time, as Goldin-Meadow (2004, p. 320) claims, 'to acknowledge that the hands have a role to play in teaching and learning' – not only in gestures and non-verbal communication, but more specifically in the haptic and tactile interaction with different objects and technological devices. Acknowledging the role and importance of tangibility and haptics in early childhood education implies addressing and assessing how and to what extent digital technologies differ in terms of their tangibility and their haptic affordances [4] from other technologies, such as, for instance, the print book, the felt board, crayons or wooden building blocks. For this purpose, disciplines and perspectives such as cognitive neuroscience and phenomenology seem to me more obviously relevant than sociocultural approaches and post-structuralist theory.

Tangibility and Haptics in Digital Technologies

In his aptly titled book *The Hand*, neurologist Frank Wilson (1998) presents compelling amounts of data from a range of scientific disciplines, demonstrating the essential role of the human hand in the cognitive development of our species. Nevertheless, more than a decade later, the importance of the hand – i.e. as manifested in the sensory modalities of touch and haptics – is still fairly neglected in both theoretical accounts of learning and cognition as well as in practical educational settings. We still tend to think of perception and cognition as relying on and relating to, primarily, (audio-)visual input. As a corollary, theories of literacy typically consider and study reading and literacy as primarily having to do with the audio-visual processing of information. However, due to technological innovations such as augmented reality (AR [5]), tangible technologies and perceptual (rather than graphical) user interfaces, it is not implausible that the long-lasting dominance of the audio-visual might soon be seriously challenged by a focus on the sense of *touch*, also in digital technologies. For instance, touch screens are becoming increasingly available also in preschools and kindergartens, to a large extent replacing older screen displays (see, for example, Romeo et al, 2003). Tangible technologies are meant to supplement and, in some respects, replace the overly visual paradigm in computer science, and to restore the lost 'touch-and-feel dimension' by designing tangible user interfaces (TUIs) which employ physical objects, surfaces and spaces as tangible embodiments of user information.[6] According to O'Malley & Fraser, tangible technologies provide real benefits for learning by their focusing on physical activity and active manipulation of objects:

Research has shown that, with careful design of the activities themselves, children can solve problems and perform in symbol manipulation tasks with concrete physical objects when they fail to perform as well using more abstract representations. The point is ... that physical activity itself helps to build representational mappings that serve to underpin later more symbolically mediated activity after practice and the resulting 'explication' of sensorimotor representations. (O'Malley & Fraser, 2005, p. 3)

In this light, the role of haptic manipulation of objects in the learning process might seem to have more obvious applicability to areas such as mathematics and physics, where learning objectives include, for instance, understanding the number conservation principle (for example, that five equals five irrespective of object categories or their spatial arrangement), or grasping the difference between geographical figures. However, the combined insights of the paradigm of embodied cognition and of Merleau-Pontean phenomenology suggest that the haptic modality plays a significant role also in other learning areas, such as reading and literacy development. This entails that a truly comprehensive theory of preschool children's reading and literacy development would benefit from being able to accommodate the whole range of sensory modalities – including those of touch and haptics (see also Allen, 2004).

Not surprisingly, there are as yet relatively few studies in the field of ICT and early childhood education specifically addressing the issue of TUIs. However, preliminary results from some recent studies indicate that there are features and affordances of AR – as exemplified by augmented storybooks – that might considerably hamper the user experience and, as a corollary, present obstacles to learning. For instance, studies by Hornecker & Dünser (Dünser & Hornecker, 2007; Hornecker, 2007; Hornecker & Dünser, 2009) of children interacting with augmented storybooks showed that the physical affordances of tangible input devices made children expect the AR objects to obey to and yield the same physical behaviour as in real life.

Observing that TUIs and physical affordances are typically assumed and commended as contributing to experiential intuitiveness, Hornecker notes:

Observations from a prior project led me to regard the assumption that interaction guided by physical affordances of the natural world will transfer directly to the world of physical-digital ensembles as too simplistic. Physical affordances may on the contrary be misleading and deceiving, if physical representations are not closely mapped to the digital elements they are connected with – they may promise more than the system is able to do, and in effect increase the difficulties encountered. (Hornecker, 2007)

As a result, the children reading the augmented storybooks often struggled in vain to achieve their aims, and the 'augmented reading experience' – arguably a major feature of AR technology – was seriously impeded (Hornecker, 2007; Hornecker & Dünser, 2009). In an earlier study of children playing with interactive toy technologies, Luckin et al (2003) explored whether and how tangible interfaces might offer collaborative support and engender collaboration. Their conclusion is somewhat ambivalent: acknowledging that the 'off the desktop' tangible experience with the interactive toys might have potential, the authors observe that the toys 'are not impressive as collaborative learning partners; their help repertoire is inadequate and even inappropriate' (Luckin et al, 2003, p. 175). Combined insights from neuroscience and phenomenology on the distinction of tangibility and the accompanying role of haptics might at least partly explain such impediments and inadequacies.

The role and importance of haptic and tactile exploration in human perception and cognition are readily acknowledged by both neuroscientists and phenomenologists. Wilson describes how cognition and learning must involve

the correlations of sensory information from retinal (light) and cutaneous (tactile) receptors ... whereby the brain actively orients the receptors in the eye or the hand toward a target of interest, and then moves them precisely during a process of exploration. (Wilson, 1998, p. 97)

In what could be called a phenomenological analogy, Merleau-Ponty (1962) describes how, when faced with some technology or thing-in-the-world, such as a pair of scissors or a needle - or, in our context, a computer mouse or a keyboard - the physical attributes of our objective body are:

potentialities already mobilized by the perception of scissors or needle, the central end of those 'intentional threads' which link him to the object given ... [O]ur body, as the potentiality of this or that part of the world, surges toward objects to be grasped and perceives them. (Merleau-Ponty, 1962, p. 106)

The (perceptual, cognitive, motor, phenomenological) tasks to be performed in order to relate to, and engage with, different objects elicit, in Merleau-Ponty's words, a kind of 'remote attraction' (1962, p. 122) from us as phenomenal bodies; our phenomenal bodies, in turn, are 'already mobilized by the perception of scissors or needle, the central end of those "intentional threads" which link him to the objects given'. Hence, digital technologies such as the computer mobilize our phenomenal bodies in very different ways than technologies with other material and technical affordances, such as building blocks, pen and paper, or a felt board. The affordances of an object, then, can be said to pertain to the very intentionality inherent in and founding our relationship with our lifeworld, in that they define something equally pertaining to both the noetic and the noematic [7] correlate of our embodied perception and cognition. According to both neuroscientists and phenomenologists, cognition and learning take place as much in the mind/body as in the world, and the totality of the human sensorium, actively exploring and probing the world, is the connecting link between the two realms.

What is the link, then, from cognitive neuroscience, phenomenology and Gibson's affordances to research on the impact of ICT on children's reading and literacy development? The key issue in this context is *tangibility*. Tangible and intangible objects – or, more accurately, tangible objects and intangible phenomena or appearances – display distinctly different affordances; hence, they most likely differ in the ways and extent to which they impact and shape cognition and learning. Comparing the experiential difference between (physical, tangible) installation art and a digital reproduction in computer-generated virtual reality, Mark J.P. Wolf (2000, p. 224) observes that 'the knowledge that something we are looking at exists before us in physical form influences how we feel about it'. The awareness that each physical object is created separately generates a very different phenomenological, embodied experience than the knowledge that with computer-generated graphics the images of the objects can be duplicated, seamlessly and effortlessly, thousands of times. Nevertheless, this experiential and phenomenological distinction between real-world contingencies and the abstract, intangible nature of digitally displayed representations tends to be trivialized in discourses on ICT and learning (see, for example, Buckingham, 2007; Rosen et al, 2008; Ito et al, 2010). In a study on three- and four-year-old children's interactions with the computer, Brooker & Siraj-Blatchford conclude:

The manipulations of symbols and images on the computer screen represents a new form of symbolic play, which the children themselves seem to treat as equally 'concrete' as the manipulations of blocks and small-world toys, although to some adults [8] ... they may seem inappropriately immaterial. The children in this study, however, made no such separation between the on-screen and off-screen world. On-screen images are 'grabbed', scolded, fingered and smacked, with dramatic effects, as part of the small-group interaction with the software. (Brooker & Siraj-Blatchford, 2002, p. 267)

In my view, the quotation marks in the quote above are essential, and also quite illuminating. They can be taken to indicate that there are, indeed, irreducible and categorical differences between the *concrete* blocks and small-world toys, and the '*concrete*' symbols representing blocks and small-world toys on the computer screen. Hence, on-screen images can be 'grabbed' and manipulated by means of a sensorimotorially separate input device, the computer mouse, whereas the grabbing and manipulation of physical blocks does not involve any such separation of action and perception (and therefore does not require quotation marks). In summary, then, there are more important, and largely neglected, aspects of the physical or real-world versus digitized representation dichotomy than 'the often voiced concern ... that technology takes young children away from playing in the real world ... and from important interaction with other children and adults' (Rosen et al, 2008, p. 102).[9] Moreover, the distinction between 'physical' and 'digital' deserves and warrants a more nuanced perspective than the typical either/or simplification.

The sensorimotor operations and the accompanying phenomenological experiences involved in the acts of building with physical, tangible blocks are different than performing the 'same' task

and operations with the computer when building with virtual blocks by clicking with the mouse and moving the cursor around on the screen. Referring to this aspect, neurologist Frank Wilson (1998, p. 310) points to the potential heuristic implications of 'bonding very early in life with keyboard, mouse, and 3-D [three-dimensional] graphics'. He declares that we do not know what might happen with children's problem-solving abilities as they are increasingly placed in front of computers at an early age

so that they can skip the 'pointless' experiences of childhood during which they find out what a baseball, or a puppet, or a toy car, or a swing can do to their body, and vice versa. We have no idea what will happen to the child who watches eye-catching imitations of juggling over the internet if that child never gets around to trying a three-ball toss himself ... The fully computerized kid may turn out to be just like us or strikingly different, as a consequence of having replaced haptics with vision as the primary arbiter of reality and having substituted virtual baseball for the old-fashioned kind *at an age when the brain's sensorimotor system hasn't settled on the time constants it will use for its own perceptual-motor operations.* (Wilson, 1998, pp. 309-310; my emphasis)

Concluding his book, Wilson (1998, p. 310) expresses concerns about the ongoing tendency in preschools and schools to 'say goodbye to the playground and the books in the school library', and makes a cautionary note about the strong commercial interests in the field of educational software for children. In a similar vein, psychologists Singer & Singer underscore the importance of children's hands-on or sensorimotor experiences in shaping and developing their sense of reality, which can then balance the other worlds they experience through different kinds of media:

The ... human capacity for conscious reflection, imagery, and fantasy depends in an important way upon a child's real world experience. The pretend play with blocks or dollhouses and construction toys is such experience in its primordial form. We can then ask how the virtual world presented by the computer can further extend our imagination or, perhaps, constrict or distort it. (Singer & Singer, 2005, p. 113)

In the same vein, psychologist Sandra L. Calvert and her team at the Children's Digital Media Center at Georgetown University have been studying the relationships between children and digital media. One project included developing two computer games, Park World and Talk World, with the intention of exploring children's preferred mode of storytelling and display, and how the different spatio-temporal modalities (for example, still versus moving images) would impact the children's recall, comprehension and enjoyment of the story (Calvert, 1999). The children got to see various stationary (for example, a tree) and moving (for example, a dog) objects on a computer screen while the teacher read them a story. Then the teacher hid the objects. The children generally preferred to play with the moving objects, and they also recalled them better. From this study, Calvert (1999) concluded that action especially helped the younger children to recall objects after they were erased from the screen. In this context, however, there is another finding that is more interesting. The study also showed that the same content presented on a felt board instead of on a computer screen led to equally effective learning performance and even more enjoyment. As Calvert observed:

the children enjoyed their hands-on activity [on the felt board], a verification of Frank Wilson's insights about the psychological and neurological importance of the hand. One implication of these results is that movement of objects is motivating for children and facilitates recall. We would propose that studies of this type support the value of action and narrative along with a 'live' teacher in helping children extend their selection, encoding, retrieval and labeling processes. (Calvert, 1999, p. 140)

This difference in tangibility, however miniscule it may seem, entails important implications for the domains of learning. In the case of wooden building blocks or figures on a felt board, we are dealing with tangible objects obeying *sensorimotor contingencies* (O'Regan & Noë, 2001) grounded by and relating to our physical lifeworld. According to the sensorimotor contingency theory proposed by O'Regan & Noë (O'Regan & Noë, 2001; Noë, 2004), each sensory modality – audio, vision, touch, smell, taste, haptics, kinesthetics – is a mode of exploration of the world that is mediated by knowledge of sensorimotor contingencies, i.e. practical and embodied knowledge of

sets of structured laws pertaining to the sensory changes brought about by one's movement and/or manipulation of objects. For instance, visual experience depends on one's knowledge of the sensory effects of our eye-contingent operations – for example, the fact that closing our eyes will yield no visual input. In contrast, closing our eyes will not change the tactile input of experience.

Our practical knowledge of the laws governing these contingencies is built up by our lifelong experience from exploring the physical environment. When moving virtual blocks around in a computer building and construction programme, the sensorimotor contingences pertaining to our haptic interaction with the mouse affect our visuo-perceptual experience at a phenomenologically distinctly different level, and in a spatio-temporally separate realm of experience, as well as of sensorimotor action. Put another way, the user input has no behavioural meaning with respect to output – clicking with a mouse is behaviourally arbitrary to the visual changes on the screen (O'Malley & Fraser, 2005). There is, then, in digital technologies, an irreducible split separating sensorimotor action (implemented as input) and cognitive, perceptual and phenomenological experience (displayed as output). When playing with physical building blocks, children can – and do – rely on their embodied knowledge of action–perception couplings, i.e. close and strictly causal relationships between the motor actions they perform on and with the blocks, and sensory perception of the sensory changes these actions by necessity cause. This coupling is dependent on natural laws pertaining to physical objects, having to do with gravity, texture, weight, etc. In contrast, when motor actions are performed in the digital environment of the computer, the sensory changes brought about are caused by digital codes and algorithmic programming underlying the connections between input (for example, clicking with the mouse) and output (for example, a folder opens or an icon yields). Such a relationship between action and perception is not dependent on natural laws, and our knowledge of these relationships is not deeply rooted in our bodies in the same way as with action–perception couplings. One step towards further explicating these differences goes through the intangibility of the virtual and the haptic affordances of digital technology. More precisely, it goes through exploring the intricate relationship between *technical affordances*, *symbol systems* and *sensory modalities*, and how these all relate to reading, learning and literacy development. According to ecological psychology, the most widely distributed human asset is the ability to learn in everyday situations through this tight coupling of action and perception (Allen et al, 2004, p. 229). Hence, if media and technologies are to support and scaffold the development and use of our uniquely human capabilities, the decoupling of motor input and haptic and visual output implemented in computer keyboard, mouse and screen seems in many ways pedagogically ill-advised. In this regard, research on the pedagogical potential of computer games is a case in point.

Computer Games, Hands-on Learning and Literacy Development

Research on computer games in general is a rapidly growing field. The same applies to research focusing on the pedagogical potential of computer games for young children. For instance, Linderoth et al have conducted a number of studies on the educational potential of computer games (see, for example, Linderoth et al, 2002, 2004; Linderoth & Bennerstedt, 2007). Interestingly, several of these studies question the widespread a-priori assumption that computer games in general and by definition provide excellent opportunities for learning, at least when the learning outcome is supposed to be the learning of specific curricular topics or content represented in the game (Linderoth et al, 2004). Due to their particular affordances, representations in computer games (for example, the text, icons and audio-visuals on the screen; 'hot spots' and links versus non-activated areas) are not experienced and interpreted by children as representations per se, but as conceptual tools for the player to act upon within the very delimited and particular context of the game in question. As Linderoth et al (2004) observe, the most basic process in computer game play is not to identify the meaning of the signs but to see their affordances in the locally defined gaming situation. As a consequence, the game does not necessarily become a conceptual tool for the children to understand the world or something in the world outside the confines of the computer game. Rather, the knowledge and literacy skills they develop can work as ad hoc concepts to act upon a concrete game play situation in a very local manner, the relevance and validity of which is restricted to this context (Linderoth et al, 2004). Hence, it seems plausible to say

that ICT may at least in some respects be a poor teacher of knowledge about the world outside the game in question (see also Plowman & Stephen, 2007).[10] Linderoth et al (2004) do acknowledge that there is learning going on also in computer games, a kind of learning that they opt to call 'computer game literacy'. However, their studies clearly indicate the potential limitations and the peculiar characteristics of such a kind of learning, which consists of 'learning the skill of handling games and developing conceptual tools in game environments' (Linderoth et al, 2004, p. 174).

Other studies in the area (Subrahmanyam et al, 2001; Kirkorian et al, 2008) have shown that computer games may promote and enhance skills such as mental rotation, spatial visualization and the ability to deal with two-dimensional images of a hypothetical two- or three-dimensional space. Repeated practice of these skills by playing computer games may hence enhance selected spatial skills. Another skill embodied in playing computer games is divided visual attention – the skill of keeping track of a lot of different things at the same time (Subrahmanyam et al, 2001, p. 12). Although playing specific computer games has immediate positive effects on specific spatial, iconic and attentional skills used by the game, we need more research to see if long-term computer and Internet use can lead to long-term improvements in cognitive and academic achievement. Most of the research on the impact of interactive games on cognitive processing has assessed short-term transfer effects, and little is known about the cumulative, long-term impact of electronic games (Subrahmanyam et al, 2001).

The ways in which computer games present a different potential for the cultivation and learning of some specific kinds of skills such as spatial skills, rather than other kinds of skills such as content learning of particular curriculum topics, can, I argue, be related to precisely the haptic affordances of the digital interface. With digital technology, we are changing the role of the hands (Mackey, 2002; Mangen, 2008); the haptic and tactile affordances of a computer are very different from the haptic and tactile affordances of any physical, material, tangible object with spatio-temporal extension and permanence (or, as a phenomenologist would say, with phenomenological depth and profiles). There is, as mentioned, an irreducible phenomenological gap between the physical manipulations with the computer mouse or the keys on the keyboard and the displayed effects that follow. The link between input and output is based on strings of binary codes and computer algorithms, and not on sensorimotor contingencies relating to our embodied knowledge. Our practical, embodied knowledge of the behaviour of the computer mouse or the keyboard does not predict, absolutely and reliably, what sensory effects will follow. When we turn a page in a book, we know for sure that the text will continue on the next page – or, at least, that the page has a reverse side that will then appear in view and replace the previous one. And when we point at a picture in a book, we can be absolutely certain that it will not suddenly disappear, or change shape, or trigger a sound (unless, of course, the book is electronically or digitally enhanced). However, when clicking on any icon on a computer screen, we may have few indications of what will happen or, indeed, if anything will happen at all (there is always the possibility of a bug in the system that could cause unpredictable changes). And we cannot be completely assured that continuing text will follow once we have clicked on the page-turner button. There is, then, a sense of uncertainty and unpredictability – manifest, and experienced, in the aforementioned phenomenological gap – between our sensorimotor action and the perceptually and cognitively experienced result of our action. The digital representation displays a kind of temporary inaccessibility encountered as an experiential potential, a latently accessible actualization of something currently unavailable, which becomes readily available with the click of a mouse. This 'urge to click' (Mangen, 2008, pp. 410-413) is prevalent whenever we interact with digital representations. As such, the links and activated icons (the 'hot spots') on the screen engender and display different affordances than they would have on a printed page, or if they were physical objects in 'real life'. This difference instills a certain psychic ergonomics (Heim, 1999) in digital technology, which is fundamentally different from that of physically tangible objects.

Such psychic ergonomics has important, and largely unnoticed and unaddressed, implications for the educational potential of digitized representations. It mandates a focus on the relation between, in particular, the audio-visual and the haptic affordances of the computer game, or educational software programme, in question. The haptic affordances of print books – turning and leafing through tangible pages of paper, tracing the fixed text line with the finger, and pointing at spatio-temporally permanent and stable depictions on a tangible surface conveying

phenomenological depth – are all adhering to predictable and naturalized action–perception couplings, and are unequivocally applicable to our embodied knowledge of the sensorimotor contingencies involved. In contrast, the haptic affordances of the digital interface are samples of artificial action–perception relationships, displaying the kinds of sensorimotor contingencies related to binary codes and algorithms, hence instilling a certain uncertainty and phenomenological detachment between action and perception. This difference amounts to more than gradually getting skilled at moving the mouse in the intended directions, and locating the right keys on the keyboard; it has significant impact on our perceptual, cognitive and phenomenological relation to digital technology. The sensory, perceptual, cognitive and phenomenological experience afforded by a digital technology is significantly different than that yielded by physically tangible objects displaying phenomenological depth and ‘absence-within-presence’ [11] – differences that might have considerable and hitherto largely overlooked implications for children’s literacy development and learning.

Doing What Science Does Best in the Service of Children’s Development

Finally, it is time to take stock. In my view, if computer games, interactive toy technologies or other digitally implemented technologies are to be supportive of children’s learning and literacy development, they have to take advantage of, and exploit, the particular strengths of the technology in question. At the same time, the technological implementations ought to strongly and consistently minimize the role and felt impact of the inherent weaknesses as these pertain to our sensorimotor knowledge and cognitive-phenomenological experience. As such, for instance, the haptic affordance of the computer – the fact that the possibility to click in important ways impacts our experience of, and relation to, whatever is displayed – benefits from being *integrated in the task to be performed*, so that it blends with the overall perceptual, sensorimotor and cognitive experience during play. This is more often the case when the task concerns mental rotation and spatial skills, or fine-tuning skills such as hand–eye coordination, than promoting and nurturing literacy skills and conceptual knowledge. Unless part of the task and learning objective itself, the haptic affordance – the mouse click option – is more likely to be experienced as a disturbance or temptation and, either way, as negatively impacting the performance and, hence, experience and potential learning outcome. Here, I suspect, we find a major part of the reason why review articles and meta-analyses show that digital learning resources have had the greatest and most positive impact in domains such as mathematics and science rather than in language, the arts and the humanities in general (see, for example, Parr & Fung, 2000; Hartley, 2007; Goswami, 2008).

Obviously, it is more than likely that, with time, we – and especially children growing up in an era of ubiquitous and pervasive computing [12] – will develop a ‘natural(alized)’ relationship to the mouse and keyboard, as well as to whatever technological gadgets the future will bring. However, as I hope to have shown, there is more to the difference between turning the page of a (print) book and clicking with the computer mouse than merely substituting a haptic (audio-)visual relationship with another of equal nature and function. The configurations of sensorimotor contingences and action–sound relationships are qualitatively and categorically different in the two devices and, hence, will inevitably yield different cognitive and phenomenological experiences and, as a corollary, different potentials for learning. In order for the field of ICT and early childhood education to more adequately address and explore the potential educational implications of digital technology, the current paradigmatic preoccupation with macro-perceptual descriptions and interpretations of the sociocultural contexts that inform and shape both the materiality and social contexts of these technologies and their representations would benefit from admitting a focus on what Merleau-Ponty (1962) terms ‘micro-perception’, which is always kinesthetic and, hence, sensory-bodily, thus privileging sensory and bodily dimensions of human experience.

In her regrettably unnoticed book on reading, *Proust and the Squid*, psychologist Maryanne Wolf (2007, p. 18) observes: ‘ultimately, the biological and intellectual transformations brought about by reading provide a remarkable Petri dish for examining how we think. Such an examination requires multiple perspectives – ancient and modern linguistics, archaeology, history, literature, education, psychology, and neuroscience’. In the same vein, in his book on the hand, neurologist Frank Wilson (1998) draws upon a range of disciplines (cognitive anthropology,

evolutionary biology, mathematics, literature and the arts, engineering and sports psychology, to mention a few). The necessity of multidisciplinary research seems, in other words, to be readily acknowledged by neurologists and psychologists. Why is the picture so different on the other side of the fence, where theorists in literacy and education keep on developing wholesale theoretical-methodological frameworks intended to replace existing ones and providing the field with complete sets of terminological, conceptual, theoretical and methodological tools? Although I will not be indicating any answers at this point, I do think it is about time we dare ask the question.

Epilogue: the fear of being normative

There seems to be a widespread and ardent political push toward implementing ICT in preschool and early childhood education all across the Western world. This makes our task of assessing the educational strengths and weaknesses of these technologies even more urgent. In my view, there is much ground to be covered and many research questions to be addressed and pursued before we can confidently claim that we are supplying practitioners and politicians with insights from substantial research and, hence, serving as beacons in the implementation process. In order to achieve this goal, I suggest that we do what science does best: namely, explain particular processes – such as, for instance, action–perception couplings and sensorimotor contingencies afforded by different technologies – and how and why these might impact learning in different ways and to different degrees, by appeal to what decades of scientific research has brought to light. In this effort, we might do well to accommodate recent insights from adjacent, but currently marginalized, disciplines, such as neuroscience and experimental psychology. Partly thanks to advances in neuroimaging techniques, research in psychology and neuroscience is now beginning to shed some critical light on urgent issues pertaining to the field of technologies and learning that are immediately relevant for the study of ICT and preschool children’s literacy development. For instance, studies in neuropsychology show how brain circuits are being rewired as we shift from paper to screen reading (Wolf, 2007); neuroimaging experiments provide data demonstrating that the specific hand movements involved in handwriting may support the visual recognition of letters (Longcamp et al, 2005, 2008); and results from behavioural experiments in psychology indicate that multitasking on the computer has a negative impact on the control of attention and memory, and on the ability to filter out irrelevant information (Ophir et al, 2009). Psychologists Singer & Singer (2005) have published extensively on the potential effects of television and computer technology on children’s learning and development. In their book *Imagination and Play in the Electronic Age*, they ponder:

Children may indeed be acquiring new psychological tastes, habits, and skills from their play with computers, but are these necessarily of longer-term value for their development? Familiarization with the use of the mouse or other features of the computer may well ease the child’s way toward the uses of a computer that are nearly essential for later school and vocational careers or for selective shopping. But serious concerns can be raised about the ultimate socially adaptive or educational value of early exposure and dependence on such technology. (Singer & Singer, 2005, p. 113)

Arguably significant reflections and relevant research findings in the field of ICT in early childhood education, research findings such as these tend to remain largely ignored. Moreover, studies such as these imply that there are justified reasons to pay more attention to critical and implicitly or explicitly normative perspectives on the ubiquitous and rapid implementation of ICT in preschool than has hitherto been the norm amongst theorists in the field. Perhaps the time is ripe to seriously question the current norm of *not* taking a normative stance. In light of what we are now beginning to learn from experimental psychology, neuroscience and related approaches within the paradigm of embodied cognition, it can reasonably be said that mainly descriptive research pointing out the *potential benefits* of large-scale implementation of ICT in preschool is in some vital respects deficient, or at the very least somewhat skewed.

Plowman & Stephen (2003, p. 150) note that: ‘an attempt has been made to avoid a technocentric approach to the discussion of ICT and pre-school children by placing this topic within a social and cultural framework’. The limitations of a technocentric approach are too obvious to warrant explication. However, the ongoing highlighting of the social and cultural

frameworks of the topic, which is so prevalent in the research literature, reveals another potential blind spot – namely, that of the individual, embodied reader/learner, defined by his/her neurophysiological and psychological architecture, inscribed and embodied in his/her phenomenological being, and acted on during his/her explorations of and interactions with objects, technologies, devices and phenomena in the lifeworld. What the field needs, in my view, is complementary approaches to the ecological focus and sociocultural paradigm (as illustrated by, for example, Yelland, 2005, 2007; Ito et al, 2010). Perhaps, by now, the prevailing focus on social interaction, scaffolding, and cultural and contextual factors has been taken as far as it can go, and emerging cross- and multidisciplinary approaches within, for instance, educational neuroscience could be indicative of emerging perspectives and paradigms that might prove at least as valuable to the field of ICT in preschool as those currently employed. The ultimate challenge, then, will reside in how to combine these perspectives and paradigms in scientifically valid, theoretically perceptive and methodologically conducive ways. In this respect, I might seem naively optimistic; nevertheless, I am envisioning a scientifically productive future in the field where we address crucial issues and assess vital aspects of the role and effect of digital technology in early childhood education by accommodating piecemeal theorizing, applying what we know from psychology, biology and neuroscience about human sensorimotor, perceptual and cognitive attributes, and how these play a role in children's sensing and interacting in their lifeworld.

There is so much more to the implementation of ICT in preschool than merely providing children with access to increasingly complex technological devices and gadgets. If we let technology and access to technology be the driving force rather than an interest in promoting human cognition, and combine this with a focus on top-down theorizing with little explanatory power, few critical perspectives and little or no normative strength, we might be about to replicate a cycle we have witnessed too many times before – from high expectations, via large-scale implementation, only to end up with disappointing results (Mayer, 2001, 2005). As Mayer (2001, p. 9) observes: 'When we ask, "what can we do with multimedia?" and when our goal is to "provide access to technology", we are taking a technology-centered approach with a 100-year history of failure'. An interest in promoting human cognition, in turn, mandates a comprehensive and nuanced understanding of human attention, perception and cognition per se, as well as how these are being impacted in a variety of ways by different technical modalities. Obtaining this fundamental knowledge requires a multidisciplinary implementation of theories on how humans attend, perceive, think, learn and act with our psychosomatic, carnal and conscious embodied mind, with artefacts and technologies in our lifeworld. My hope for a truly interdisciplinary future also in the field of ICT and early childhood education is neatly summarized by yet another neuroscientist, Adele Diamond:

We need to pay more than lip service to the complexity of human experience. We must keep our minds open to observations and developments in related but currently separate fields of study and actively promote interdisciplinary approaches and collaborations. The possibilities for building and nourishing connections among the social, cultural, neuroscientific, biological, and cognitive sciences in the service of understanding children and their development are tremendously exciting. (Diamond, 2007, pp. 157-158)

We have, indeed, an astonishing Petri dish of powerful technologies in front of our eyes and at the end of our fingertips. The crucial question is how we decide to handle them – theoretically, methodologically and pedagogically.

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Notes

- [1] The term 'affordance' originates from the ecological psychology of J.J. Gibson (1979), and denotes the opportunities for action and interaction with our environment. Largely by courtesy of Donald

Norman (1988), the term is commonly applied in the field of human–computer interaction (HCI), where it typically refers to the possibilities for interaction with the digital interface as they are perceived by the user (Norman, 1988, 1990).

- [2] See also Yelland (2007), who argues for the relevance and employment of postmodern perspectives in the critical discussions in the field, focusing – among other things – on gender and multiculturalism.
- [3] Haptics denotes the tactile perception through our skin combined with the perception of the position and movement of our joints and muscles (commonly referred to as the kinaesthetic sense modality). Usually referring to the tactile perception and exploratory movement of our fingers and hands, haptics is commonly known in industrial design, ergonomics and HCI as ‘haptic feedback’, as, for instance, when devices (for example, mobile phones) respond to input by vibrating.
- [4] In line with the above definitions, ‘haptic affordance’ denotes the way in which the interface of a technical and material device invites and requires manual interaction from the user (reader).
- [5] AR is a field of computer research dealing with the combination of real-world and digital bits, allowing you to interact with computer-generated three-dimensional content implemented in real-world objects – such as, for example, a book or a writing desk.
- [6] The Tangible Media Group at the Massachusetts Institute of Technology expresses the goal of TUIs as changing the ‘painted bits’ of GUIs (Graphical User Interfaces) to ‘tangible bits’, taking advantage of the richness of multimodal human senses and skills developed through our lifetime in interaction with the physical world’. See <http://tangible.media.mit.edu/projects/>
- [7] The noetic–noematic correlation, originally conceived by Husserl (1982), denotes the relation between the subject’s act of experience and the experienced object. ‘Noetic’ refers to the act of experiencing; ‘noema’ to that which is experienced. ‘Noetic’ thus refers to the subject (or experiential) correlate, and ‘noema’ to the object correlate. The noetic–noematic correlation is what is uncovered by phenomenological reflection on the nature of intentional acts and their objects. Furthermore, this correlation, or intentionality, is invariant to our experiences.
- [8] By ‘some adults’, the authors refer to the work of psychologist Jane M. Healy (1998, 1999).
- [9] See also Buckingham (2007, p. 45): ‘[the arguments stemming from the critics of computer technologies] are normative, in the sense that they implicitly contrast the use of computers with a more “natural” or “healthy” approach to childhood rearing ... Computers are deemed to be a poor substitute for direct hands-on experiences and for the reading of books – another “second-hand”, potentially isolating experience which is somehow exempted from this criticism’.
- [10] Plowman & Stephen (2006) observe that there were few examples in their data of what they term the ‘proximal dimension of intended learning outcome that could be classified as knowledge of the world: interventions were rarely explicitly cognitive in orientation, such as developing learning in terms of content, and most interactions were operational. Knowledge of the world is often mediated through talk and ... we did not observe many learning conversations’.
- [11] ‘Absence-within-presence’ is a central notion in Merleau-Ponty’s (1962) treatise of perception, and refers to the invisible parts of tangible objects and how these play a significant role in phenomenological perception. Tangible objects are always only partially visible for us, and their currently invisible parts can become visible with movement. This absence-within-presence is what gives a tangible object its phenomenological depth, hence distinguishing material objects from intangible phenomena on digital displays.
- [12] ‘Pervasive computing’ refers to the way digital technology is becoming embedded in our physical surroundings (for example, ‘smart walls’ and wearable computing in clothes) rather than being located in a single platform and device such as a desktop or laptop computer.

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