Early Childhood Digital Play and the Zone of Proximal Developmental Flow (ZPDF)

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This paper is fundamentally concerned with the nature of digital play, the question of its potential for learning and development, and in the educator's role in supporting such play. The paper argues that, from the evidence currently available the most effective pedagogy to be employed in early childhood should be in support of extended free play strongly 'seeded' through the provision of an appropriate rich and accessible technological environment, and supported by educators and/or more capable peers who provide positive role modelling, and short periods of focused instruction and demonstration. In developing practice further, more needs to be done to clarify the educational aims of ICT in early childhood, and to identify more fully the developmental prerequisites of complex operational thinking across the curriculum. A few suggestions are made regarding the most appropriate schemas to be applied in supporting children's future learning in computer studies and coding.

Introduction

A large body of research in the USA and UK (Bowman et al.'s, 2001, McCarrick *et al*, 2007, Bhavnagri *et al* 2009, Siraj-Blatchford. & Siraj-Blatchford, 2005, Morgan et al, 2011) has provided evidence that preschool practitioners can support young children directly, and also support parents indirectly in developing the digital home learning environment. Most importantly, the extant research has also shown that digital learning can lead to measurable gains in child outcomes between the age of 3 and 5. Yet, as Plowman and Stephen (2005) have suggested, concerns with digital play have often centred more around the extent to which the technology enhances or inhibits development than with the kinds of play afforded. Research associated with children's passive consumption of entertainment technology, and studies carried out to seek correlations between 'screen time' and less positive child outcomes have been carried out and provide sobering reading (Siraj-Blatchford and Morgan, 2009). A review of the literature carried out by the US National Association for the Education of Young Children (NAEYC) and the Fred Rogers Center (2012) identifies particular concerns related to the encouragement of obesity in young children but also makes the important point that today 'all screens are not created equal'. Much of the extant research has been concerned with the passive and sedentary consumption of television and desktop computer games. But as Stephen and Plowman (2014) have observed, the distinction between children's digital and embodied play has increasingly broken down as;

"..a new generation of technologies with tangible (i.e. touch able) interfaces facilitating seamless movement between digital and non-digital resources and play narratives".

As Siraj-Blatchford and Siraj-Blatchford (2006), NAYEC (2012), and Stephen and Plowman (2014) also note, developmentally appropriate early childhood educational technology promotes curriculum integration and activities away from the screen so that digital and non-digital play is often integrated. Even where fixed screens are applied, the children tend to make little separation between their on and off screen play:

"On-screen images were 'grabbed', scolded, fingered and smacked, with dramatic effect, as part of the small-group interaction with the software. In some instances, they took on an off-screen life of their own, as children continued the game the computer had initiated, away from the machine" (Brooker and Siraj-Blatchford, 2002, p267).

The overall position adopted in this paper is therefore consistent with that of the NAEYC (2012) in suggesting that:

"Technology and interactive media are tools that can promote effective learning and development when they are used intentionally by early childhood educators, within the framework of developmentally appropriate practice (NAEYC 2009), to support learning goals established for individual children".

Mainstream preschool practice in ICT

While there are many individual centres demonstrating some really excellent preschool practice in the UK, such practice remains exceptional as a review of preschool ICT practice carried out by Plowman and Stephen in 2005 found:

"Children's use of computers (the dominant form of ICT in the playroom) nearly always happened during free-play periods and was characterised by brief and often unproductive encounters. Children frequently experienced operational difficulties, were hampered by their inability to read instructions or respond to dialogue boxes and failed to complete tasks when the games or activities they were interacting with were too conceptually demanding".

Similar findings have been noted in other countries, e.g. in Spain (Tena, 2014) and were also noted a few years earlier in the UK *Effective Performance of Preschool Education* (EPPE) project. *The EPPE qualitative research of twelve preschool settings that were identified as particularly effective in achieving positive learning outcomes included* over 400 hours of naturalistic observations of staff and 254 systematic focal target child observations (Siraj-Blatchford et al, 2002). The study found that the most effective preschool settings combined the provision of free play opportunities with more focused group work that involved adult direct instruction, and that adult-child interactions that involved some element of 'sustained shared thinking' were especially valuable in terms of children's early learning. These were identified as sustained verbal interactions that were most commonly identified in practical activity so that it might reasonably have been expected that they would often occur in the context of children's use of ICT. Unfortunately the evidence suggested that too often there was no adult present when children accessed the technology and little or no scaffolding and support was provided (Siraj-Blatchford et al, 2002). The ‘effective’ strategies that practitioners had developed in these settings to supporting the children in terms of cognitive and social development tended not to be applied in the context of ICT. In most cases adult support was limited to intervention when the children experienced problems or required supervision. The children were generally left to work independently, with the practitioner providing encouragement, questioning, instructing and managing only when required. This isn’t really surprising given the fact that much of the early childhood software currently available has been developed specifically to encourage the child’s independent activity. That said, there are exceptions to this: www.madeinme.com/the-land-of-me/

In a review of the evidence on the use of ICT in the EYFS carried out for BECTA in 2008, Aubrey and Dahl (2008) found that:

“Practitioners would like and need more professional development in ICT to promote learning across the EYFS. They need training in:
- *the use of specific hardware and software;*
- *development of greater awareness of specific types of adult interaction that actively mediate, expand and encourage children;*
- *provision of routine guidance and technical assistance”.* (p5)

Practitioner training for ICT has sometimes been found to be extremely effective. In Northhamptonshire for example, ‘Lead Reception Teachers’ were trained to play a key role in supporting other schools in their local clusters (Ager and Kendall, 2003). One notable feature of this projects success was that the quality of the play provisions more generally, and not just related to the ICT provisions, were considered to have improved:

“Across all the schools, it seems that the quality of play experiences generally, not just those with a central focus on ICTs, have been improved by the initiative. Teachers have been re-energised by the project's focus on play and in several cases they have radically re-assessed what they provide” (Siraj-Blatchford and Siraj-Blatchford, 2006).

One of the key findings of the Northmptonshire study was that practitioners needed to become more aware of the learning related to the early years foundation stage (EYFS) gained using ICT before they were able to engage in the process of supporting and scaffolding it. Similar evidence was reported in a 2004 evaluation of 117 preschools across the five European countries. The study provided a random, representative (20 per cent) sample of those involved in the KidSmart (corporate philanthropic) Early Learning Programme:

“We asked about the time that adults spent providing children with extension activities or stimulus, providing modelling or demonstration and in reinforcing what the child was learning. While a few (8%) UK and German teachers reported modelling and some reported extension work, it is clear that this kind of

support is relatively rare in most settings" (Siraj-Blatchford and Siraj-Blatchford, 2004).

Ironically, in each of the countries that were surveyed, the amount of time the practitioners spent with the children at the computer actually reduced as a result of the initiative and this was identified as a result of the 'child friendliness' of the Riverdeep software that was supplied with the IBM hardware. Digital tools might at times have been considered to act as a pedagogical replacement, rather than as providing pedagogical support to practitioners.

There has also been some confusion regarding the educational aims of ICT. In the UK such confusing has, arguably, not always been restricted to the early years of education. As Heppell (1999) argued, the mistake has often been to look at computers as *teaching machines* that teachers must learn to operate rather than as learning tools that may be judiciously applied. The subject was first introduced in England and Wales as an element of the Design and Technology National Curriculum, it was then given the status of a subject in its own right, with a strong focus on learning about, and how to operate technology. The 'Early Learning Goals' in the Curriculum Guidance for the Foundation Stage (CGFS) (QCA/DfEE, 2000) first suggested, that children should be finding out about, and identifying the uses of technology in their everyday lives, although it did also suggest that they should be using computers and programmed toys to support their learning. But the overall emphasis came to be on encouraging children to learn about the technology and this may have served to obscure the major role to be played by ICT as an educational technology.

Research does however provide a wealth of individual examples from preschool practice and from homes where digital play involves children with adults and more capable peers interacting together with clear learning aims in mind. For example, research carried out by Falloon and Khoo (2014) reports on Puppet Pals HD being used to support the recounting of stories; Pic Collage, for summarising learning from a unit of celebrations; and Popplet for story plan development. A wide range of examples are provided in Siraj-Blatchford and Morgan (2006) and Sung et al (2015) show how parents and children can learn various digital literacy skills from each other; how to navigate particular Apps, how to manipulate programmable toys and in activating and controlling Wiis and other player movement games. Some applications such as the Open University Our Story app, lend themselves very strongly to this:

"In one project carried out in England, a mother created a digital story together with her three-and-half-year old daughter, based on the daily routines depicted by a toy clock. While the child was very skilled at audio-recording the narrative accompanying her story, she needed her mother's help with typing the words. In one of the exchanges, the child taught her mother how the App worked, while the mother showed her how to type some difficult words.
Child: Rosie? [The girl is typing random letters as part of her story]
Mother: No, t-t-t for tortoise. Here! [mother types T and adds it to child's writing]"

(Sung et al, 2015)

Stephen (2010) has discussed the two enduring ‘big ideas’ related to pedagogy in early childhood; child-centred freedom of activity choice, and play. She cites Bowman *et al* (2000) and Siraj-Blatchford and Sylva (2004) in arguing for some degree of adult activity initiation, and ‘sustained shared thinking’ (p18). Evidence from Bennett et al (1997) and BERA (2003) is also cited to question the weakness of a good deal of free play practice in terms of supporting learning. Yelland and Masters (2007) have also identified children’s need for cognitive, technical and affective scaffolding to help keep them on task and encourage higher levels of thinking when using technology.

Both Vygotsky and Piaget saw play in early childhood as an important symbolic capacity building process. The sort of development that they considered was required for a child to learn complex operations such as reading were considered by both of them to be result of the child’s creative and constructive playful interactions with a progressively challenging environment. They both took entirely for granted the idea that complex cognitive operations were ‘emergent’, they were achieved as a result of significant prior learning, but more than the sum of these parts (Sawyer, 2003). In the case of reading, the foundations for learning are set in the pretend play of young children, in their manipulation of objects symbolically, as they at first let objects ‘stand in’ for each other, and then in the child’s playful interactions with a progressively challenging print culture and environment. As Davis & Tall (2015) explain taking the example of a child learning how to count:

“Our brains take as basic data for reflection the records of our previous experience, and just as we categorize visual perceptions from cup-like things into the category of cups, so we categorize patterns of action such as directed movement with synchronized standard utterances into the category of counting” (4).

In a study carried out investigating preschool learning using Alphablocks (Siraj-Blatchford and Palmer, 2011) a major challenge for phonics education in early childhood was identified in the paucity of training, and the present capability of early childhood educators to teach phonics appropriately. For Vygotsky (1978), and for Wood, Bruner and Ross (1976), child development could be supported by an adult (or more capable peer) ‘scaffolding’ the child’s cognitive achievements within her ‘zone of proximal development’ (ZPD). Vygotsky’s ZPD has come to be recognised as defining the space between what the child is able to achieve on their own, and with guidance and support.

Significantly, the AlphBlocks digital play environment was found to provide scaffolding for the adult as well as for the children:

“It was found that whilst the researcher and practioner worked alongside the child to facilitate dialogue and screen interactions, there resulted a “meeting of the minds” where subsequent learning was occurring on both sides”.

In these, and a wide range of other studies children have been found to be engaged and motivated for longer periods of time in digital play than they have been with other more traditional educational activities

(Siraj-Blatchford and Whitebread, 2003, Siraj-Blatchford and Siraj-Blatchford, 2006, Siraj-Blatchford and Morgan, 2009, Sung et al, 2015). They were often carried away with what they are doing, and a much deeper level of involvement and learning was occurring. These qualities are characteristic of free-flow play, and provide further confirmation of the relevance of Laevers' (1999) application of Csikszentmihalyi's (1979, 1990) concept of 'flow' in describing the complete immersion, involvement and sense of fulfilment of young children in play. Montessori (1965) had clearly made similar observations at the end of the 19th Century when she encouraged free-flow play through her three-hour uninterrupted work cycle. Laevers has argued that this total involvement can only occur within the zone of activity that matches the child's capabilities, their zone of proximal development (Vygotsky, 1962), and that it stems from their:

"…exploratory drive, the need to get a better grip on reality, the intrinsic interest in how things and people are, the urge to experience and figure out" (Laevers and Heylen, 2003, p15).

Basawapatna et al (2010) have confirmed the relevance of Csikszentmihalyi's (1990) work to education more generally, and applied a 'computational thinking pattern analysis' to provide their (middle school) students with progressive challenge through 'a gentle slope of increasingly complex projects'. In combining the psychological concept of Csikszentmihalyi's Flow, with Vygoskys socio-cultural notion of the ZPD, Basawapatne et al (2010) refer to an optimal Zone of Proximal flow (ZPF), that promotes the children's intrinsic motivation and maximise their learning experience. We prefer to refer to this as a Zone of Proximal Developmental Flow (ZPDF) and argue that the concept can equally be applied in the general (i.e. not simply digital) case of free-flow play where the child's playful learning is scaffolded by their recall of schemas developed through prior instruction, observation and experience. This self-scaffolding process thas also been identified in research by Tharp and Gallimore (1991).

Schema's and 'emergence'

To understand the ways in which children's early learning and development contribute towards the emergence of various complex operations it is useful to consider more fully the 'schemas' that Piaget (1962) considered provided the building blocks of conceptual development:

"Schemas of action [are] co-ordinated systems of movements and perceptions, which constitute any elementary behaviour capable of being repeated and applied to new situations" (Piaget, 1962: 274).

Piaget recognised that every element of knowledge was 'connected with an action' (1971, p6), and he referred to assimilation as a process whereby the child made sense of the world in terms of the particular stock of schemas that they had acquired so far. Piaget recognised that sensory input was a function of the child's active exploration, that this was a process directed by anticipatory schemas, and that when the child's expectations of assimilation were not met, their schemas were elaborated to accommodate the experience. Gibson's work on perception and ecological development (Gibson, E, 1960, Gibson, J, 1979) later provided further evidence of the primacy of the child's actions, and their perception of the possibilities (or affordances) for action, and Neisser (1976) elaborated this further to describe a cyclical process of perception. He also realised that there is a reciprocal link where knowing facilitates doing and doing facilitates knowing:

"The schema is not only the plan, but also the executor of the plan. It is a pattern of action, as well as for action" (56).

All of this may be considered consistent with Vygotsky's notion of the tools of intellectual adaptation that are gained from the surrounding culture. For Vygotsky, child development was considered to involve a progressive internalisation of, and adaptation to, the culture that is primarily achieved through language (Rogoff, 1990). The implications of this for education are, as Bodrova and Leong (2007) have noted:

*"... the tools are learned from adults and suggest that the role of the teacher is to 'arm children' with these tools. This sounds simple, but the process involves more than merely direct teaching of facts and skills. It involves enabling the child to use the tools independently and creatively. As children grow and develop, they become active tool users and tool makers; they become crafters. Eventually, they will be able to use mental tools appropriately and invent new tools when necessary" (*Bodrova and Leong, 2007: p***4.)***

Following, and somewhat adapting, Neisser (1976) and Anderson (1977), we may identify the following as the main characteristics of these mental tools or 'schema' as they are more often referred to:

- they are organised in a meaningful way;
- they are embedded within superordinate and subordinate schemata;
- different schema may be applied in the course of an interaction with the environment;
- schema are reorganised when they commonly or *calamitously* fail to be useful;
- they are emergent and gestalt mental representations, they are more than the sum of their parts, and they tend to reify and bias our perceptions.

The term schema was also applied in the pioneering work of Chris Athey (1990) who identified a number of repeated and intrinsically motivated patterns of children's behaviour in play, which she named according to their characteristics such as 'enveloping', 'rotating', 'going under and over' etc. Athey identified these behaviours as reflecting schema, and argued that the children's use of these schemas should be encouraged and facilitated by the materials on offer in the environment, and through the support of adults. Athey (1990) hoped that providing educators with knowledge of schemas might help them to meet the needs and support children's learning more appropriately. As Nutbrown (2006) has explained:

"If a child is say focussing on schema related to roundness, we could say that the child is working on a circular schema. The form is 'roundness' and the content can be anything which extends this form: wheels, rotating machinery, rolling a ball…" (Nutbrown, 2006: 11).

In practice the pedagogic implication is that as the adult encourages the child to apply the schema they are encouraging further assimilation. The popular literature on schema theory and practice also makes some reference to learning that may go beyond assimilation, and might be interpreted as encouraging the accommodation of schema as well. As Athey put it, “schemas become co-ordinated with each other and develop into systems of thought” (Athey [1990] 2007). Meade and Cubey (2008) take the example of the ‘back and forth’ schema;

“…seen in a toddler who brings items and dumps them in the lap of a familiar adult. These may become coordinated (or ‘connected’) later with ‘going and coming’ between home and the early childhood centre. Added together, these two periods of exploring ‘transporting’ schema may form the foundation of map-reading that is developed in middle childhood”. (p50)

Piaget (1962) believed that as a child encountered each new experience, s/he referred at first to their prior knowledge to make sense of what an object ‘does’, and then what an object ‘is’, although it was only in his later work that he differentiated between the two and suggested that learning involved a progressive cyclical process in the development of figurative or symbolic ‘schema’, and their *operative* ‘schemes’:

“The terms ‘scheme’ and ‘schema’ correspond to quite distinct realities, the one operative [a scheme of action in the sense of an instrument of generalization] and the other figurative” (Piaget, 1969: ix).

So called 'schema practice', as it is commonly applied in early childhood education, currently involves the practitioner in at first identifying and then encouraging the child's operative 'patterns of repeated behaviour', into which new experiences are then 'assimilated and gradually co-ordinated' (Athey 1990, p37). But it arguably provides no pedagogic consideration or account of the figurative source, or products of these patterns. In fact, in the 2007 edition of Athey’s text on schema, she acknowledges that:

“If more were known about the build-up of coordinated schemas [schemes] and concepts [schemas] more would be known about how best to teach some of the key concepts of the curriculum right through schooling” (Athey, 2007: 114).

Schemes and schema’s should both be recognised as being constantly revised and elaborated upon as the child encounters new experiences. As Furth (1969) explained:

"The child who re-enacts a scene from yesterday represents through symbol formation the event which was yesterday present to him through object formation…It gives food to his growing operative thinking which otherwise would be limited to perceptual events of here and now" (Furth, 1969, p89).

In a neurological sense the brain/mind is constantly working to build and rebuild itself as it adapts and modifies new experiences and information (Fishcher, 1980). In a thoughtful consideration of schema theory, Grenier (2009) draws attention to the findings of the *Cambridge Primary Review* of research evidence (Alexander et al, 2010):

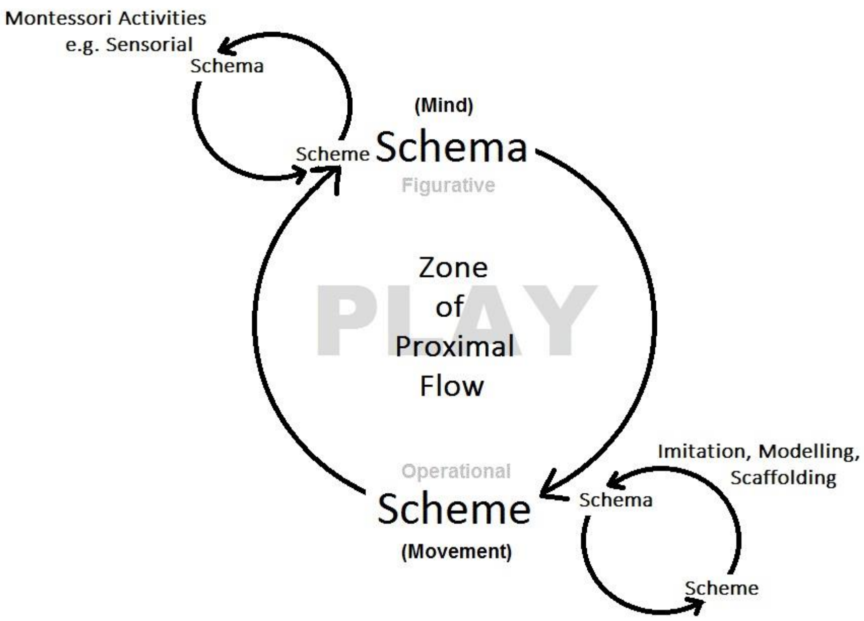
"Piaget's recognition that children actively construct their knowledge of the world through their action upon it has been upheld. As Gosawmi and Bryant explain, the discovery of 'mirror neurons' (brain cells which fire both when a person performs an action and when they observe someone else performing it) indicates that sensorimotor knowledge is the starting point of cognitive development, but that it is augmented rather than replaced by symbolic representations 'gained through action, language, pretend play and teaching'" (p91).

The principle of emergence explains how the sophisticated and complex cognitive operations that emerge in children are irreducible to their component schemes and schemas. But it is important that we recognise that they still act as developmental precursors to those operations, even if they must later be drawn together in the child's mind as a unique and individual creative act of conceptual learning (Siraj-Blatchford and Brock, 2015). This perspective is consistent with that of Maria Montessori in her identification of 'sensitive periods' of development, and it also provides a theoretical rational for her prescription of focused instruction in 'presentations', followed by extended periods of free play. The focused activities serve to provide affordance schemes for the children to subsequently explore freely in relation to a variety of schemas in their play. The practice may also be considered consistent with the 'free flow' play recommended by *Bruce (2004)*, *which provide opportunities for them to;*

*"..*try out their most recently acquired skills and competences, as if celebrating what they know" (p132).

Yet Montessori identified a series of 'sensitive periods' where such patterns are typically displayed, and can be encouraged through focused tasks, and her free play 'work cycle' appears to mirror contemporary 'schema practice' in being concerned to encourage the application of these operative patterns in new schema contexts.

The diagram below provides a figurative representation of the analytic model that we have so far developed (Siraj-Blatchford and Brock, 2015). The zone of proximal flow, defines the opportunity space in free flow play that opens up when the child is able to draw upon a new schemes and schema. Applying the cyclical account of the learning processes involved, we should note that this internal scaffolding includes recalled operational schemes and figurative schema, and further learning takes place through a recursive engagement between the child's actions in the physical world and their emerging understandings of these actions.



The figure shows, outside the ZPF, the source of the cognitive functions being applied in the play. They may be developed through focused learning activities, they may be deliberately scaffolded by the adult, or be simply some imitation of behaviour that the child has observed.

From this perspective, the task of the educator in supervising free-flow play within the ZPF will be to provide access to stimulating materials and environments and, through additional modelling or scaffolding, whatever additional (light touch) input the child requires to stay within the ZPDF. In a busy classroom where several children are engaged simultaneously in free-play, such a demanding adult role might be considered analogous to 'plate spinning'.

Conclusions: Towards an emergent ICT education in the EYFS

In his classic book Mindstorms, Seymour Papert (1980) describes how the operation of rotating circular objects and gears against each other was extremely influential in his early childhood. He describes how he 'fell in love' with gears and was constantly turning wheels in his imagination and making chains of cause and effect. Papert drew particular attention in recounting these early experiences to the affective dimension and how the 'magic' of his play with gears provided him with a lifelong positive disposition towards mathematics and technology. The playful immersion, *involvement* and sense of fulfilment that he describes experiencing in these activities are consistent with Csikszentmihalyi's (1979, 1990) description of creative flow as referred to above. The 'gears' that Papert refered to as providing 'models' may equally be considered schema, and for Papert, the gears that he played with in his mind were recognised as providing powerful schematic structures that supported his future learning and development in mathematics, science and technology. It was this recognition that he drew upon in creating Logo, and the first programmable turtles developed as other 'objects' for children 'to think with'. Since logo, further work has been done to create similar 'microworld' learning environments with the intention of engaging young children in their own cognitive development (Roblyer, 2003). Lego's MindStorms, provides a notably example, one simplified version of which motivated and empowered one group of children at Reggio Emelia's Villetta infant school to give a branch that had fallen from a tree after a heavy snow fall 'another kind of life' (Chioccariello et al, 2004). An observation paralleled by Turkle (2011) in her book 'Life on the Screen'.

In his discussion of the gears of his childhood, Papert went on to speculate about how a 'Modern-day Montessori' might provide similar 'transitional objects', in fact he did so himself, with the early LOGO turtles and we now have their modern equivalents such as BeeBots. Floor turtles serve to connect cognitive operations just like Papert's gears:

"…with the 'body knowledge,' the sensorimotor schemata of a child. You can be the gear, you can understand how it turns by projecting yourself into its place and turning with it. It is this double relationship--both abstract and sensory that gives the gear the power to carry powerful mathematics into the mind" (Papert, 1980).

Contributory work has been carried out in a number of disciplines, and significant efforts have been made to identify key skills and concepts (Purpura and Lonigan, 2015). With emergent literacy providing a model for other subject areas (Teale and Sulzby, 1986), Whitebread (1995) promoted an emergent perspective in early childhood mathematics education, and Siraj-Blatchford (2000, 2001) argued for an emergent approach to be adopted in early childhood science and technology education. What is now required is to pull all this research evidence together to provide a more coherent and comprehensive early childhood curriculum, and to identify more adequately conceptual progression across the curriculum, and the developmental prerequisites for that emergent progression. The identification of appropriate digital tools to support both the presentation of new schema, and the opportunity to freely play with them within the ZPDF must logically follow these efforts.

As Stager (1999) has observed, LOGO has provided an object to think with for both the learner and for the people who are thinking about the thinking of the learner. This is equally true of other digital learning contexts, the development of appropriate focused activities depends upon the adult’s awareness of curriculum progression, and it also depend upon the quality of the practitioners observations of the child’s current application of schemes and schemas. Montessori’s identification of sensitive periods, pre-defined didactic materials and activities has provided valuable scaffolding for practitioners following her tradition. As Papert said, what we now need is a modern day Montessori to complete the task. Attempts have been made to provide similar support for EYFS practitioners in the UK DfCSF (2008) *Practical Guidance for the EYFS* that are now included in *Development Matters* (BAECE, 2012), with supporting statements presented under three columns:

- ‘A Unique Child: **observing** how a child is learning’;
- ‘Positive Relationships: **what adults could do**’; and
- ‘Enabling Environments: **what adults could provide**’.

But as Athey (2007) noted as cited above, there is still much to be done to identify the specific schemes and schema that should be developed as developmental precursors to emergent complex operations later in school. Papert studied under Piaget and he came to recognise what should now be considered a fundamental law of learning; that intellectual structures grow out of one another and in the process acquire both logical and emotional form.

This is a principle that should of course be applied as much to technology education as to educational technology in early childhood. In the UK, digital play should be applied to support the new National Curriculum for Computing. The first step must be to identify the developmental prerequisites for coding. The overall aim of a computing curriculum is that pupils become digitally literate: ‘able to use, and express themselves and develop their ideas through, information and communication technology’ (Department of Education, 2013). A major objective is also to promote ‘Computational Thinking’, for children to learn to model problems in a way that makes them open to computational solutions. . Computational thinking is:

"[...] a mode of thought that goes well beyond software and hardware, and that provides a framework within which to reason about systems and problems" (Computing At School, 2012). In fact CT involves concepts and skills that lie at the heart of computing, such as thinking in the abstract, the decomposition of problems, pattern matching, generalization, inference and algorithm design. 'Computational thinking' requires abstraction; and especially the need to break down a problem into stages to solve it, and it is important to recognise that this demand for mental abstraction isn't unique to ICT. Decomposition provides the same cognitive challenge as breaking down a story or narrative on a story board, and the Open University 'Our Story' app referred to above provides an excellent means to support that. Children can also identifying the different stages of activity (the 'algorithm') that is involved in making cakes or play dough. Recipes provide an introduction to programming and floor turtles. In addition to programmable toys there are also PCs, laptops, tablets and smart phones that have screen 'turtles' to control, and programming apps such as Daisy the Dinasaur, Cargo Bot, and ScratchJr that are already being used by some preschools.

Given the ubiquitous nature of digital teachnology children's early learning about programming should surely also begin with learning about electricity and electric circuits (circular flow), about switching things 'on and off', and then progress on towards learning about programmes and programming (i.e. how things are switched on and off in sequence). A simple and familiar example to most readers is the programme that runs in a domestic washing machine (Siraj-Blatchford & Whitebread, 2003).

Again, as Papert (1980) suggested:

"Anything is easy if you can assimilate it to your collection of models. If you can't, anything can be painfully difficult"… "What an individual can learn, and how he learns it, depends on what models he has available".

Research suggests that digital tools can contribute significantly towards supporting children in their wider educational achievements. But if we are to improve the scaffolding of learning and support in our pre-schools, it will not be enough to simply respond to the observation of the child's schemes by presenting them with additional schema applications. As Vygotsky argued, we should not wait passively for children to learn; education should *"march ahead of development and lead it" (Vygotsky*, 1962, p 104).

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