Emergent Science and Technology in the Early Years

Ciencia emergente y Tecnologia en la edad infantil

Science et Technologie dans l'enfance

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Introduction
Socio-constructivist perspectives in early childhood education (e.g. Sayeed & Guerin, 2000) recognise the importance of viewing play as an activity where children are developing their confidence and capability for interacting with their cultural environment. If we are to provide for an appropriate, broad and balanced education in the early years we must therefore first think about children playing, but then we must also think about the particular subjects of that play. The principle has major implications for the early years curriculum as a whole, but in this paper the implications for Science and Technology education will be especially emphasised.

The importance of providing a more appropriate 'enculturation' of young people into the rapidly changing scientific and technological culture of the 21st Century has been widely recognised throughout the world. This recognition can be seen clearly in the National Curriculum developments in the UK, and the issue continues to be the subject of major concern (ASE 1999). My intention here is to develop this further specifically in terms of early years practice. The argument presented is that an 'emergent curriculum' should be recognised as a curriculum responsive to children's needs as individuals, a curriculum that accepts diversity of experience, interests and development. An emergent curriculum is also a curriculum that respects the power and importance of play, and supports children in becoming more accomplished players; good at choosing, constructing and co-constructing their own learning. Dweck and Leggett (1988) have shown that young children evaluate their achievements in term of learning products or performances. Children who become oriented towards learning goals are found to be masterful in the face of difficulties whereas those orientated towards performance tend towards learnt helplessness.

The kind of *emergent* Science and Technology promoted here is very much like emergent literacy (Hall, 1987). Teachers who teach emergent literacy encourage 'mark making' as a natural prelude to writing. This is precisely the way Froebel and many other early educational pioneers saw the importance of learning through 'making' things. In emergent science we can also encourage 'explorations' and support the child in sustaining these explorations over time. Teachers who teach emergent literacy usually *read* a range of different kinds of text to children: In emergent science and technology we should introduce the children to new phenomenon, new explanations and artefacts. It is important that we provide them with the essential early experiences that they must have if they are to go on to understand scientific and technological explanations later. These early experiences will include playing with a range of different materials (sand/water/air etc.). They will also include drawing children's attention to the workings of their own body and to both the natural and the manufactured world around them.

Imagine how difficult it would be to understand the science of atmospheric pressure if you had never gained confidence in conceiving of air as a substance in the first place. To support children in this respect we can encourage 'air play' in the nursery, pouring air upside down in water, playing with bubbles, and balloons, and bicycle inner tubes, by watching the wind, and by catching it in kites and sails. In the same way we can also take children on visits to show them laboratories and workshops, and we can draw upon their experiences of parents interactions with technology at the supermarket checkout, bank cash points etc in creating play environments in our settings.

Teachers who teach emergent literacy also provide positive role models themselves by showing children the value they place in their own use of print. In emergent science we can do the same by talking about science and by involving children in our own collaborative scientific investigations. In terms of technology, we can involve the children in making things, and in developing computer applications that help us in our day to day work. We can also tell the children many of the historical stories of scientific and technological discovery. In doing so we will encourage children to develop an emergent awareness of the nature and value of these subjects as well as positive dispositions towards the science and technology education that they will experience in the future.

Many of those promoting emergent literacy see parent and teacher 'modelling', that is teachers and parents providing good role models to be the most important factor in developing children's capability. They therefore encourage parents to read to their children and to ensure that the children see them reading for their own purposes. This is backed up by numerous large scale research projects that show that the single most influential factor in determining children's future academic success in the early years is the parents reading to children and taking them to the library regularly (Sylva *et al,* 2000). This in turn is related to social class and other factors - but the primary determinant seems to be the parent's behaviour; change that and it may compensate for social class differences in academic achievement. So the real challenge is to provide children will strong models of science so that they develop positive attitudes and beliefs about the importance of the subject, because it is that which influences their motivation to engage in it.

'The child as scientist'

In the past some writers have fallen into the trap of talking of the child 'as a natural scientist' (Bentley & Watts, 1994) because of their natural inclination to 'spontaneously wonder' (Donaldson, 1992) about things. Driver (1985) addressed this directly in the *Pupil as Scientist* and as she went on to suggest, we now know that some of these beliefs differ markedly from accepted scientific knowledge and that they may also be difficult to change. But the major difference between the scientific knowledge that every individual child builds up as an infant and the science constructed by professional scientists is related to the rigour with which every new idea is tested and to the benefits of collaboration and communication.

'Established' scientific knowledge is the product of a collective historical enterprise. When we refer to science as a 'discipline' we are making reference to a set of rules: For a child (or for anyone else) to think 'scientifically' means to try there best to obey these rules and to; keep an open mind; to respect yet always to critically evaluate evidence; and; to participate in a community that encourages the free exchange of information, critical peer review and testing.

In developing our early years practice we must be especially vigilant in distinguishing between science and scientific development, and cognition and cognitive development; which however analogous is actually quite different. It is important in this context to remember that constructivism is a learning theory developed in opposition to inductivism; the idea that we simply absorb new understandings directly from the environment. And the crucial word here is 'understandings', Piaget (1969) actually said that empirical knowledge *might* be acquired simply through observation, but that the learning of explanatory rules and concepts relies upon the self-conscious co-ordination of the observed with existing cognitive structures of meaning.

Learning science is not simply knowing about 'natural phenomenon'. It provides a set of socio-historically established and agreed logico-mathematical constructions that explain these phenomenon. From the constructivist perspective; as an observation is recognised as in some way inconsistent with a cognitive structure or schema, that schema may consequently be reorganised to accommodate it. This elaborated structure of meaning may then, in turn, be applied to explain the observation, which is itself, transformed in the process. The whole process of learning is a mechanism of 'equilibration' and it is disequilibrium, 'dissonance' or disturbance that provides the motor for encouraging the process. But the fuel of that motor is the child's interest, and it is important to recognise that their motivations cannot be taken for granted, and may be extrinsic or intrinsic in the activity. DeVries (1997) in particular has drawn special attention to this aspect of Piagetian thinking.

Too much science teaching in the past has been based on a naive assumption of 'discovery learning'. In the high school Physics class children have been encouraged to balancing copper 'pennies' on a balance in order to learn the law of moments and in nurseries and kindergartens water tanks are sometimes set for children to play with and 'discover' why things float and sink. This makes all kinds of assumptions about children's prior knowledge and understanding, and just as significantly about their motivations and interests. But we are never passive in perception: We can look at things scientifically, or critically, or with appreciation, we can also look at things poetically... and we can view things with indifference or with a view to remembering them, promoting or even changing them and as Donaldson has suggested:

"…theoretical preconceptions and reported observations are by no means independent of one another. Theories – or, indeed, beliefs not conscious enough to be called theories – guide the nature of the observations; and the guiding assumptions are often not recognised as being open to doubt."

(Donaldson , p161 1992)

In a study of 5 year olds playing with construction kits (Siraj-Blatchford, J & I, 1998), even with the very modest scientific conceptions that were involved, we found that 'instruction' was far more influential than 'discovery'; although the kind of instruction that was observed included hidden learning processes such as the observation of peers. Free access to sand and water play are very popular in the UK, they can undoubtedly be influential but all the evidence suggests that the play involved is, as often as not, repetitive, irrelevant and unproductive. For this sort of play to be educational in terms of science some form of instruction (e.g. demonstration, modelling etc.) is usually needed, and clear objectives need to be defined.

From the simplistic notions of individual cognitive elaboration through 'discovery' we have therefore increasingly come to see child development in socio-cultural terms as a 'construction zone' involving the educator and not just the child Siraj-Blatchford & MacLeod-Brudenell, 1999).

There is now a consensus in the UK that the quantity of scientific 'facts' that we attempt to teach is too great, and that more should be done to teach children about the nature of science and about the processes of scientific knowledge construction (ASE, 2000). For the early years we need a play based curriculum that takes us beyond the assumptions of 'discovery'. Play is a 'leading activity' (Leontiev, 1981, Oerter, 1993), and as van Oers (1999) has suggested, when children consciously reflect upon the relationship between their 'pretend' signs and 'real' meanings they are engaged in a form of semiotic activity that will provide a valuable precursor to new learning activities (p278):

"…learning activity must be fostered as a new special form of play activity. As a new quality emerging from play activity, it can be argued that learning activity has to be conceived as a language game in which negotiation about meanings in a community of learners is the basic strategy for the acquisition of knowledge and abilities". (van Oers 1999, p273 authors own emphasis)

From this theoretical standpoint I want to argue that we should be providing opportunities for children to play at being scientists and technologists. Science is a game with rules just like any other and children are already playing at being Mummies, Daddies, as well as a wide range of traditional roles such as that of Soldiers, Doctors, Nurses and Firemen. In the UK, pre-school suppliers and toy shops produce 'dressing-up' clothes to promote this kind of play and it's about time children played at being scientists and technologists as well. We can afford to exploit the stereotype a bit here (as long as it isn't gendered), and provide play resources such as big plastic test tubes, test tube holders, burettes, coloured water, weather observation equipment, electrical sensors, construction equipment etc., and encourage children to play with them. For some practitioners even this will seem to prescriptive, but as Vygotsky argued:

"In one sense a child at play is free to determine his own actions. But in another sense this is an illusory freedom, for his actions are in fact subordinated to the meanings of things and he acts accordingly"

(Vygotsky,1978, p103)

One of the biggest problems that we have faced in British science early years science education has been the educators concern that they themselves don't have the prior knowledge that is needed to either answer children's questions, or to teach them science. Hodson (1998) has written about the need for teachers to accept that in providing either the 'correct answer', or the 'established scientific view', isn't always a practical option. Given the pace of scientific development perhaps it isn't something we should assume that we are doing at any stage. Anne Edwards and Peter Knight (1994) make the point even more strongly in the case of Early Years education by saying we should only ever be trying to move children from their initial limited conceptions to 'less misconceived' ideas. This may be obvious in the case of learning about physical concepts such as floating and sinking: While a recognition of 'upthrust' may represent a necessary prerequisite to learning, any adequate understanding of the science must involve the concept of Density. And this is only understood when children are able to consider the effects of comparative changes in volume and mass (the intellectual equivalent of rubbing your stomach and tapping your head at the same time).

This is a difficult idea for many early years educators and provides another reason why we should quite clearly differentiate between science education that focuses on established conceptual knowledge (in the UK national curriculum this currently starts with 6 year olds), and an 'Emergent Science education' that focuses on the development of emergent conceptions of the nature of science and the development of positive dispositions.

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