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The emergence of scientific and technological awareness in the early years

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Abstract
This paper forms part of a much larger case study into the emergence of design capability in the early years, with particular reference to modelling. In order to try to analyse design capability I identified fifteen different design behaviours and looked for evidence of these with the subject of the case study, Joe. It was begun when he was two and a half. He is now four years and eleven months old. In the paper I have drawn together evidence from some of these behaviours.

Introduction
There are many definitions of science and technology. Wolpert’s definition is that,

‘...science produces ideas whereas technology produces results in the production of usable objects’ (1992:25)

There is a tendency to link science and technology, but the partnership is a fairly modern one. Wolpert says that,

‘Technology... is very much older than science. Unaided by science, technology gave rise to the crafts of primitive man, such as agriculture and metalworking... not until the nineteenth century did science have an impact on technology. In human evolution the ability to make tools, and so control the environment, was a great advantage, but the ability to do science was almost entirely irrelevant’ (1992:25)

Similarly, children’s own early technology is not underpinned by scientific theory. They produce usable objects by exploring materials around them, and assembling, dismantling and rearranging components and materials to hand without the benefit of scientific theory. None the less through their play they begin to acquire a working knowledge of the world, the way it behaves and functions and part of this working knowledge is science related and concerned with the properties of materials and how they behave. This scientific awareness is acquired through observation, making connections between things by perceiving similarities and through a process of trial and error as they explore and investigate the world around them. Technological awareness is developed by actively applying their science related knowledge by creating usable objects, and overcoming difficulties by trying things out. They may also express their technological awareness through identifying how things work and how they are fastened together.

In order to be able to create things that exist in physical space children need to have a working knowledge of a range of materials both liquid, solid and gaseous, such as water, air, clay, sand, paper, wood and many more. They also need to have an awareness of how materials might be fashioned, formed, made composite, and fastened together. They also need to understand how things already in existence work in order to inform their own designing and making.

In order to construct models of their world to aid their understanding of it, then they need to be able to make connections between things and events and this is something they continually do from childhood onwards. Learning takes place, ’by generalizing from examples’ and as Pinker also says, ‘The power comes from the generalization according to similarity’ 1994:416. This generalization is based on our capacity to pattern seek and use.

Pattern seeking and using
From a very early age children are active in exploring their environment and begin to construct models or, as Gardner (1991) puts it, ‘homespun theories’ of their world. Their ability to do this relies on the capacity of the human mind to actively seek out regularities, making connections between things and events. As De Bono says 1976:84,

‘Pattern is the basis of not only how the mind works but how the world works’

Pinker 1994 believes that ‘a sense of “similarity” is innate’ and that this gives us a ‘general multipurpose learning device’.

This learning device helps us to classify, to memorise and construct our own models of the world. In order to perceive connections then we need to be able to observe similarities between things, but as Pinker 1994, points out the similarities are ‘in the
mind of the beholder... not in the world’. Hence we do not all necessarily perceive the same samenesses.

Our capacity for creating mental images allows us to make comparisons between things and events. Our ability to ‘see’ more than the present, coupled with the richness of social communication allows for ‘the anticipation of future states and for planned behaviour. With that ability comes the abilities to model the world, to make explicit comparisons and to weigh outcomes’ Edelman 1992:133

My study of Joe began when he was two and a half years of age and I was continually struck by his ability to perceive the similarities between things, a prerequisite for constructing models of the world. Joe’s second word was ‘switch’. He would use this to signify not only a switch but a pull switch, a zip and a ring pull on a can. A button was definitely not a switch as this did not accord with his ‘switchness’ of switch as it did not function in the same way.

Joe continued in his pattern seeking and using process. At 3.3 we were walking along a gravelly path which Joe described as ‘wrinkly’. He made a connection between the texture of his skin in the bath and the texture of the path so building up a tactual and visual schema for things that possess poss the properties of ‘wrinkliness’.

Another pattern to emerge at the same time was one based on function. We had played ‘dotting’ with sticks in the garden when I told Joe that we had to put them back on the ‘stick pile’ under the tree. When we came to the tree Joe told me to put my stick in the ‘stick pantry’. After all it was a storehouse for sticks. Three months later we went to look at some fish. On seeing a bewhiskered catfish Joe pronounced it an ‘insect fish’. In the same month Joe moved on to using similes. On seeing a circular rug, he commented, “Rugs are like moons aren’t they?” A ladder fern was described as being like a fountain, round biscuits were like Button Moons and when they broke he put them together ‘like a jigsaw’. A circular fan was like a spoon because of its roundness and an orange paper dragon was like a fire. When Joe was four years of age we were travelling in the car over the moors. We had to be careful that the bees, which were in abundance, did not get into the car through the open windows, so Joe said,

“We’ll have to close the windows. The bees might see the rounds on us and think we’re flowers”.

This perplexed me. I had obviously not seen the pattern that Joe had seen. When questioned as to what ‘rounds’ were Joe replied that they were our noses, ears, eyes, and mouths. The pattern observed therefore, was one of shape. As De Bono says, 1993:48,

‘Once the stable pattern is established .... then any input which is at all similar will be recognized. The thing to be recognised does not have to be exactly the same...’

Early models of the world: the emergence of scientific awareness

This capacity for continually seeking out patterns and regularities helped Joe to construct his own science oriented models of the world.

At 3.3 Joe was playing with a jug of water in the garden. He threw the water over the plants, saying “It’s melting”. Without any prompting he add that tap water melted. It appeared that his concept of melting related to running water. Two weeks later Joe was drinking orange juice while I had a cup of tea. As I poured the tea I asked him if it was melting. The response was no. When asked why, he replied that only water melted! A week later Joe was carrying a full jug of water. I pointed to the water in the jug and asked him if it was melting. He said no. When I asked him why not, he replied that it was because the jug had not got a bottom. This I took to mean that the water could not escape or run from the bottom of the jug.

A month later he was drinking clear lemonade. I pointed to the liquid in the glass and asked him if it was melting. He said,

“No, but it melts in your mouf when it goes down”, indicating a route from mouth to stomach.

At the same time rain was said to be melting when it ran down windows and off roofs. The pattern seemed to be well stabilized in relation to his model of melting, that is, it had to be water (or look like water) and it had to run. A slight shift occurred when one day he was eating an icecream. When asked the usual question he said,

“No.... yes. Only when I eat it and it goes down”.

When playing a game of dipping sticks in a bucket of water, I pointed to the water in the bucket and asked him if it melted. The reply was “Only when it drips (off the stick)”.

When Joe was 3.10 he was eating an icecream and observed himself that it was melting. I asked him what made it melt.
"Warm makes it melt. Lollies melt as well. They melt wiv drink”.

Here there is another shift in the pattern. It is evident that Joe perceives heat as a requirement for melting and that a solid can change its state. Joe is now 4.11. Recently I held up a painting of his in front of the gas fire to dry. Some paint began to drip. “It’s melting, look,” he said. I asked him what happens when something melts. “It drips”. I then began to ask him what kinds of things melt.

“Ice, metal..” Apparently he knew that metal melted because he had observed that on television.

“Wood can’t, and men, chairs, umbrellas, jumpers..... rain can’t”. At this point I asked him if rain dripped as he had described this as a feature of melting.

“Yes, but it doesn’t melt”.

Does paint melt? To this Joe replied,

“No, I was tricking you!” Clearly he had ‘read’ the hidden question and been able to think about his thinking.

This is as Joe’s model of melting stands now. He has been made to think about his thinking, and whether everything that drips melts. A previously stabilized pattern has been temporarily destabilized.

At 3.7 Joe became fascinated by another material-air. This began with playing with the bubbles in the bath and being asked what might be inside them. I told him that it was air and explained that it was all around and hid in secret places like bubbles. I explained that we couldn’t see it but we could feel it and we began to blow on our hands. Two months later we were sitting in McDonalds. Joe was drinking through a straw, out of a plastic container with a lid when he said,

“If you blow dere it breeves”.

He had observed the lid go up and down as he blew into the container. I asked him what had made it do that. “Air” was his reply. Here he had obviously made a connection between the movement of his body during breathing and the movement of the lid and air.

Two months later we passed a trough of water, the surface of which was rippling. When asked what was doing that he said, “Wind” and said that wind was made of air. I asked him if air could move things and he replied, “Trees... and bits”. As we walked back to the car he noted that my hair was blowing with the wind.

One week later Joe was about to put his hand in a packet of crisps. I asked him what was inside the packet. To my amazement he replied air. I then asked him what else and he replied crisps. When Joe was asked later why we needed air he said, “Make fings breeve... and move”.

On another occasion Joe was playing with a piece of elastic so we began to try things out for stretchiness. Joe pulled the top of his socks. I asked him what was inside, “Air” he said, without hesitation. He later added ‘plastic’ meaning elastic.

Clearly Joe is actively making sense of his world by constructing his own meanings, related to his own experiences. This accords with a constructivist view of learning (Scott et al 1987).

The emergence of technological awareness

At the age of one year and eleven months Joe was observed tool using, trying to pick up a pine cone using two sticks. He persevered for a full ten minutes until he was able to move the cone a short distance. This persistence was to be displayed time and time again. Sticks as tools and materials were to be a feature of his early technology.

At the age of 3.3 Joe tried to put a long stick inside a small plastic bug box. I asked him if he thought that it would fit. He said ‘Yes’, tried it and it did not fit. He then tried to fit it in horizontally. This did not work either. I asked him what else he could do and suddenly he had found a solution based on knowing something of the properties of most sticks. They snap. This solution worked.

A year later Joe was observed on a family video waving a stick in the air, assessing its properties. This stick was flexible. He put one end in the ground, bent the stick over and poked the other end in the ground to form an arch. He stood back to observe his work and pronounced it a bridge.

When Joe was 3.4 I presented him with a new toy, a water pump. I gave it to him while he was already standing at the sink, his hands in a bowl of water. I gave no indication of what it was or did and suggested he find out. First he turned the handle. Nothing happened. He then began to examine the pump from top to bottom. I asked him what he thought the spout was for. “Water”, he said. He then began to plunge the pump up and down very carefully and soon noticed the water level rising in the pump. He
then spent 25 minutes making drinks and he internalised his actions, committing the process to memory by saying, “It goes up and up, and up and up in there and out there”.

Joe from the age of three showed an awareness of things being fastened together to produce a shape or form. In this observational drawing of a tiny plastic car he adds dots to the line to fasten the line together. He calls these dots pegs. I think he is also aware that the car requires fastening together.

Fig. 1

In the following drawing of a car he again indicates a technological awareness in that he knows that the car is made up of components, tyres, wires and an engine. He also knows that it needs something to make it go: petrol. This shows that he has an awareness of the innards of things.

Fig. 2

Joe from the age of three showed an awareness of things being fastened together to produce a shape or form. In this observational drawing of a tiny plastic car he adds dots to the line to fasten the line together. He calls these dots pegs. I think he is also aware that the car requires fastening together.

Fig. 3

He told me that the picture, here showing Sonic the Hedgehog, went down the tube into the ‘saw’ (the circular bit) and then onto the tape. I am still not clear what a ‘saw’ is, but it was definitely round. Here Joe has offered his model of the way a piece of modern technology works. Many adults would be daunted to offer an explanation of the products we take for granted. As Koestler 1964:264 says, ‘Modern man lives isolated in his artificial environment... By being entirely dependent on science, yet closing his mind to it, he leads the life of an urban barbarian’.

This awareness of things having inner workings was also evident when one day he was playing with a small wire bike, using the pattern of the carpet as a road. When the bike came to the imaginary traffic lights, he made a clicking sound to indicate that they were working.

At four years four months Joe was playing with his stickle bricks. He made a model and added a horse and a propeller to the wall of the model. When asked what the propeller was for, he said, “Colding you down and hotting you up”. I asked him how it did that.

“Well, the electricity’s in the walls and that makes it go”.

At the age of 4.11 Joe was drawing and as he did so he told me that his mother was videoing him something. Without prompting he then began to offer an explanation of how the picture was transferred from the television to the videotape. I told him that I couldn’t ‘see’ what he was saying so I asked him to draw it. This is the drawing.

Joe from an early age was willing to offer alternative solutions to situations presented to him, particularly through a story. He always had an answer to such questions as ‘How do you think Apron Man might get Annie Apple off that tree? How do you think that little boy might get that hedgehog out of that cattle grid? Very often Joe would turn the model round on me and ask me such questions as “How might you get into that rocket... if it’s flying?” Or “How might
Bouncing Ben get over the river to kiss Clever Cat?” so that he became the problem finder rather than the problem solver.

**Conclusion**

In the early years we need to find ways of accessing children’s existing ideas whether in science or technology so that we can utilise them as building blocks and create shifts in their patterns of thinking as they continually assimilate and accommodate new ideas and experiences. We also need to help them develop their awareness of the ways in which they think and encourage them to be not only problem solvers, but problem finders.

**References**