Contemporary Issues in Science and Technology Education

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Chapter 16: In the Beginning, Interpreting Everyday Science

Abstract

This chapter explores ways in which children begin to learn science in its different manifestations from their earliest days. It recognises that science is inextricably intertwined with other STEM subjects. The importance of out of school learning is recognised including in museums of the widest genre. Above all, it stresses the importance of hearing the voice of the child, not ignoring it and their own understandings. In the beginning the youngest children observe and make sense of their world, including the science action in their lives. Hence, Science understanding upon which the theory can be built if formal education is available. The earliest interactions with everyday science are Experiences, but are the foundation for future understanding and learning These are the foundation on which science teachers can assist the learner in school of constructing the knowledge of the curriculum in teaching situations. This chapter explores ways in which children begin to learn science in its different manifestations. Above all it stresses the importance of hearing the voice of the child, not ignoring it and their own understandings. Listening to the child, not telling them, scaffolding their scientific literacy development and acquisition of science capital.

Key words

Sciences, early years, child's voice, formal school, informal sites, play, progression

16.1 Introduction

The beginning of experiencing science in action begins from birth. The youngest of children observe and make sense of their world. The actively engage physical science actions but a observe effects of earth science, biological organisms and phenomena, experiencing the biology in action in themselves as a living being Such learning is observational and experiential. Adults, the available media and other venues such as museums, zoos, gardens and indeed the everyday environment. are sources of information. Informal science is now a recognised part of learning about science for all ages.Such experiential learning is the laying of their foundations of their scientific literacy and understanding. It is different to formal school science. Should schools seek to develop the child's observations and experiences in school rather than teach the conventional science curriculum as most countries prescribe? UNESCO suggested schools should build on the science most relevant to everyday life such as human biology and health, climate science. With the human, largely developed countries, issues confronting our planet isn't such understanding essential for sustainability and survival? Abrahams (2021) asked the question of science being fit for purpose now with so many of the UK and other countries 's public not understanding about disease, transmission, immunity and prevention in the Covid pandemic, apparently not having been taught such at school many adults. In essence the starting point for learning science is play However, the recognition and study of Early Childhood education has been largely excluded from the attention to opportunities for learning science and associated subjects (STEM) but such is beginning to be recognised as critically important (Milford and Tippett 2015).

16. 2. What is Science Learning?

Where does this occur? Should science be taught from the earliest stages of formal education to school leaving? This was the question posed (Eschach and Fried 2005). The concept of science as only an artificially conceived set of subjects in school and learning such restricted to such is unrealistic. Science is observed, experiences and learnt in different places: formal school in the statuary years of education, in out of school locations designed to provide learning opportunities, science and natural history museums, science centres, zoos.. Science in action is experienced and observed in leisure time from various forms of media, the internet, televisions. Books and observing in the community or joining particular leisure activities with a science content. Science is evidentially based. Children either in preformal school settings such as kindergarten or nurseries, or on their play at home and in communities do collect various aspect of evidence as they interpret observations and outcome. Much early science is also identifiable as early maths and engineering,

Monteira and Jiménez-Aleixandre (2016) worked with Spanish children aged 5 to 6 years of age in a Kindergarten class engaged in science practices with practitioners and found that these children could distinguish between evidence from their own observations, in this work on snails, named purposeful as opposed to the empirical evidence from planned investigations with the teacher. Some formal education practitioners value play activities , recognising that for these early formal learners science ideas and practice are integrated with familiar early years strategies such as story telling, Vartiainen and Kumpulainen (2020) identified aspects of scientific play during activities with a preschool group in Finland which were inquiry based within sessions designed within imagination and play activities identifies characteristics of what they named as scientific play. Carruthers and Worthington (2006 wrote about the beginning of mathematical understanding. The so-called children's science (Osborne et al., 1983) takes place in children's engagement with the world in which they live and to which they give meaning through their actions, experiences, current knowledge, and language. This sense-making takes place through the search for similarities and differences, through the organisation of events and phenomena, and through the observation of their environment. In this way, children collect data in a certain way, look for explanations, form models and make predictions. The tremendous compelling curiosity of these youngest of children before formal teaching and their implicit desire to understand their living and inanimate environment is what drives children to explore their environment actively, curiously, and generously, albeit more unsystematically and less stringently than scientists.

Science as a concept has constituent parts. We do the whole superordinate category harm by treating it as a uniform entity. The most important category to recognise in the beginning is the biological domain because we, practitioners and learners in this specific case, are biological organism but in our physiology and anatomy utilise principles of the physical domain. We experience biology in action which can provide a personal point of view when o]encountering and observing together biological organism and systems. As living beings we observe natural phenomena have shaped our species. Earth science has formed then natural environment provide biomes and climates in which organisms live as well as the weathered and other climate function which affect us. These systems to utilise the content. We also encounter and co-exist with the other inhabitants of this world, other organisms, some beneficial to us, some not so and some seeking to live in harmony. It is important for educators to understand both the ways in which beginning learners acquire information and their ideas about their everyday world, and that children come not to our lessons as *Tabular Rasa* but as children scientists.

16.3 Formal and Informal; science learning opportunities

Finding out, learning about Science may occur in three distinct locations:

1. Home,
2. Other venues either purpose built for dissemination of information- science museums, cultural museums, botanical gardens, zoos and aquaria .
3. In formal education settings which are implementing governmental policies and practice.

Children spend far less time in these formal learning establishments than they do in the informal ones. Hence, informal learning is an important part of developing science capital and complementing school learning. Formal learning occurs within school including within auspices of the school as part of the curriculum but out of school on activities in the grounds around the school, outside the classroom. It also occurs in other venues such as the wide genre of museums. Informal learning occurs beyond the auspices of the school, and in leisure time in the learner's community or at home. However, in out of school venues other educators consider whether or not the learner has voluntarily visited the site or whether they are conscripts led by educators(Smith et al 1998). However, children taken to a museum by parents or carers during out of school time or in the case of preformal school learners, in playgroups or childcare situations are in fact conscripts too because they are taken, although on occasion a young child asks to be taken, often a repeat visit go for example a pond or zoo. Children's playgrounds are a site of experiential STEM learning.

Ros Driver published her seminal book, The Pupils as Scientist in 1983 (Driver, 1983) which revolutionised thinking of secondary (11-18 years) science teachers in the UK about their teaching. Driver pointed out that secondary pupils had ideas about science learning and the pupil (of secondary age) was a scientist. These pupils came to formal school science lessons with relevant experiences and their understanding, albeit not always in agreement with the interpretation of scientists of the same phenomenon. In the last third of the last century changes happened in science education. A paradigm, shift recognising that presecondary children in school were also capable of learning science taught in appropriate ways. ICASE started the presecondary science section in 1988 at their Canberra meeting. It is the first quarter of the twenty-first century that acknowledgment and understanding that pre-school children also experience and display intuitive science has emerged. Two science educators founded the Journal of Emergent Science in 2012 in the UK to cover reporting of relevant research in science learning for this age group and their practitioners. A similar move occurred in the through the National Science Teachers Association (NSTA). Alison Gopnik through publishing her research in a form accessible to practitioners through her books for a general readership which reorganise that youngest of children are through their activities show the attributes of sconce investigations (Gopnik, 2012) School science is but one aspect of science in the world. Remarkably even practicing scientists fail to recognise science in action in their lives considering it to be that which is restricted to laboratories or field research. Towards the end of the first quarter of this present century the realisation that the earliest of years child is also actively involved through play and everyday tasks in experiencing Science, Technology, Engineering and Maths in action (STEM) is leading to innovatory practices, policies and research.

The term science is frequently used to cover STEM areas (science technology, engineering and maths education. The recognition of which has become prominent in the first decades of the twenty first century, recognising that these areas are often inextricably linked. The rigid division emerged in the second part of the 19th century, between the Science and Arts subjects. It is now being broken down gradually. In the nineteen eighties the Government of the United Kingdom's introduced a national curriculum which included science and design and technology, to be taught from the statutory start of school at five years and the Early Years framework for children under five in preschools included Understanding about the World. Increasingly, in the primary schools (5-11 years of age) science activities embrace what is often now referred to basic engineering, incapsulates some of the maths concepts as well as practicing some maths skills such as measuring collecting data contrasting tables and graphing recuts. Early formal schooling focuses on developing literacy in language, speaking, listening reading and writing as well as basic numeracy and other mathematical areas But does not recognise and link these STEM areas as shared exeriences.

Moreover, the traditional content of science teaching is increasingly being challenged. The surge of a media environment and issues of economics and climate change is challenging further the content of science curricula. Such observations have led to the recognition of an increasing involvement of citizens through for example social media, and in some cases citizen science projects An understanding that science relevant to the people is involving them in active participation unlike school science formal teaching. Thus, a realisation that science in the community and media is also the tool to have an informed citizenship who can participate with understanding in decisions. Increasingly with this Science in the community outside the formal school set up, educators are challenging the content of science teaching relevant for most pupils. There are fears the school leavers level of science literacy is inadequate to grasp the issues of the present times and school since should perhaps focus on the a more focused functional scientific literacy that should be developed and evaluated in schools'. These most recent thoughts were prompted by the Covid-19 pandemic where understanding of viruses, immunisations were largely lacking.

A constraining influence on Education policies and practice in many countries is the effect of the neoliberalism polices of many governments (Roberts-Holmes and Moss, 2021). A business model is applied, and accountability measured by test results of the children, publications of league tables of school examination results, as well as inspection reports. In England more and more schools being taken under the control of boards of business people looking for financial results as they establish Academies, often in groups, which receive finding directly from the government and over which the Local authorities, hence the people through their elected members, have no control or input. The child is the only player in this scenario who is not consulted but the object to be educated to satisfy the demands of the system in place.

16. 4 In the Beginning

16.4.1 First Encounters with Science for a Child.

Increasingly practitioners and others are recognising the importance of understanding and facilitating the first experiences of the youngest children with science in its widest sense in their everyday. However, we are part of biology as are a biological organisms. As a child develops they tend to interpret much of the biology they encounter anthropomorphically transferring what they understand as their needs, rather like Maslow's hierarchy, found, such as froglet needs a home, but constructs such in the fashion of his western human house. Such anthropomorphic interpretation is carried on by many adults in their interrpoetaion of animal behaviour, particularly domestic pets and in talking about many zoo animals particularly the primates. There are three dimensions of becoming aware and beginning to interpret everyday biology by young children this awareness is not uniform. Tunnicliffe identified three dimensions, namely: Time, Observations and Systems from her observations of pre-school children and their 'biological encounters in their world.

There are no knowledge boundaries in these emergent leaners making sense of their world, so the divisions of formal school curricula in science is not apparent to them. Progression in understanding meets no barriers. Physical Science and cause and effect in their physical interactions with toys and everyday items whereas however interactions observational at this stage rather more a phenomenon of a very young child then biology which is only evidenced to them in their everyday functions, particularly eating, excreting, temperature needs and society The majority of toys with which Western children play require pushes and pulls in the early stages. It is not only toys with which the early learners interact but also with everyday objects such as doors, which, if open and the child can crawl, they push open or closed., using and experiencing a force in action. If they have a toy with wheels they learn of pulls and of tension. Pushing a wheeled vehicle by hand over different surfaces the child experiences the effects of friction. These are but a few examples of physical science in action.

Physical science is the predominate domain in action play with toys, which is optimally free choice. Letting object drop to the floor they experience the effects of gravity but also having the toy returned to the child is they are seated in say a pram or highchair, the child begins to collect data and begin developing the scientific process. Earth science becomes important in the youngest child's experiences. The change between day and night, weather patterns and how they affect the toddler with a need for appropriate clothing and activities allowed provide experiential learning. Although there are some hands-on earth science experiences such as sifting silt, collecting small stones and pebbles, playing with mud, walking on different surfaces and elevations, noticing landscapes, much is observational as is biology in their world other than first-hand experiences of themselves in life processes. These domains are less frequently apparent in early years setting whether the physical domain is predominant. We practitioners have to consider carefully how earth science and biology can realistically and constructively become part of a child's experiences form birth. As soon as children meet objects, they begin to experience shapes, mass, size, colour, different materials. In their explorations and early play for example with blocks they are experiencing fundamental maths concepts and ,most importantly, spatial thinking (Pollman, 2010) and also in the structures they build with toys and then in adventure areas they are intuitively using engineering principles, When exploring their environment or playing with toys for instance, children use a variety of approaches that show similarities to those used by scientists such as observation classification for data collection (Gopnik, 2012). Without science aware practitioners so much children's science learning associated with play, free choice or in learning environments is not recognised. Science in action experience is part of play (Tunnicliffe and Gkouskou, 2019).

16.4.2 Play

Play is a universal activity of the emergent learner, in some mammals including we humans. The type of play, location and particularly toys used, varies. Adults have an influence on a child’s play in some ways. Researchers maintain that play in ancestral communities and in some present day indigenous people is an apprenticeship for adult hood and the children play with adult items in miniature whose use is important in adult life, (Riede et.al 2018). Young children in many societies also re-enact adults actions and behaviours with miniature objects. Play is associated with the children initiating it themselves not adults instructing. The Pre-school years are often popularly regarded as “Just playing”, not real learning whereas others are beginning to easier that play in the preschool years is a vital stage in a child’s development and involves much STEM learning though experiences. Play is Play. We can identify in play elements not only of the STEM subjects but also signs of socialisation, problem solving and physical development and progression. Number, measurement, space, and time are important math concepts. As preschool children learn through play and the world around them they are experiencing STEM basics. It is the adults who become concerned about what the child is learning, they are giving the actions labels. There is commonality of early interactions whether they are labelled maths, science or engineering, such as making collections, constructing towers that are stable

. The child’s idea of number is associated with length, space occupied not by individual present. Children begin to understand How much How many? Block play helps the early learner lean about balance measurements and space and shapes and number. The role of an adult with a young child is important in using maths words in everyday life, counting how many of something for example, the blocks they have, the number of a particular colour, example toy cars they have, how many times they have collected in their basket as they come to the end of a rush around a room punishing the doll’s pushchair. Hearing adults say the words when cooking for example, measuring out ingredients or collecting the slices of bread to make toast is important, or at play group the number of mugs to put on a table for their mid-session drink.

These types of dialogue can be heard by older pre-school children in some countries early years settings, themselves when role playing in say, a home corner laying the table for tea for their toys or in playgroup for another child. Children enjoy sorting matching and counting everyday things like bottle top, counters and putting items in a container and taking them out again. They make sets according to their own system, like putting all toy cars in one place and all toy animals in another. Measuring is very important and involved in play. Water play is very much a science and maths activity pouring form one sized container to another and then to different shaped containers but of the same volume. Children develop maths concepts gradually and through experiences in play. Number, measurement, space, and time are important math concepts. As children learn about them, they are learning about the relationships among objects, and about their own relationships to objects and to the world around them. We use numbers to find the answer to the question, “How many?" Using numbers comes naturality children. They enjoy counting how many items they are holding, or how many children, or family in a home situation. They might say, "One two, four, seven,” using names they have heard but are not quite sure of their meaning as they count out four plates for example. Children who practice counting lots of things have an easier time learning about numbers. They also enjoy making collections, stones and pebbles, toy cars, sticks or leaves and often such collections can be used to develop ideas of science, particularly botany and earth science as well as descriptive words and counting, adding, subtracting, multiplying, and dividing up the components of such collections listening to the child’s thinking out loud. Young children's ideas about spatial relationships are very much based on how it looks to them. The youngest child has to realise, which they do about one year, that even though they can no longer see an object. It still exists. A three-year-old with their understanding is of what they can see. They learn directions when they want something they cannot see, like their coat, or toy

16.5 The STEM Play Cycle Free Choice and Progression

16.5.1 stages in a STEM Play session
Play is not uniform in several ways. First of all, the term play is a superordinate category covering the activities of young children observing and interacting with phenomenon, natural such as the weather or constructed such as everyday implements or items, toys, created specifically for children by adults, and frequently not used in the way the adult envisages. Secondly, It is progressive in understanding, capabilities and skills experiences are honed and developed. play is not the same from the earliest years to adult hood. Play is progressive as skills and understanding. Thirdly, play interactions depend on the interest of individual children.

The initial but critical stage in a child ‘playing’ is that their interest is ‘caught’ and subsequently maintained so they enter into an interaction with the phenomenon. This which is the basis of the person-object theory of interest (POI), where the initial interest elicited by the first encounter is caught. This theoretically is the Theory of interest, The interest represents a particular interest, particular to that child, between the child and then phenomenon, usually an object. It included   initial attention to the item, interacting in a task and, if included, requires maintained curiosity and engagement. Whilst widely applied in museum work with visitors at exhibits, this theory is pertinent to play. Much 'science’ focused play and indeed activities in play groups and nurseries with constructed equipment are of a physical science manifestation involving pushes, pulls, essentially using sources which are powered by the energy from the child’s play social action. Hence, I developed the play sequence or cycle. My STEM play cycle has distinct identifiable stages can be identified in observing children at play and is being used by CASTME. There are variations depending on the science inherent in the experience and interest object or phenomenon. The key starting point   is the child intrigued and explores the artefact or phenomenon   that they encounter.

INSERT   HERE Figure 16.1 The STEM Play Cycle

INSERT TABLE 16.1 Here

Table 16/1 The science (STEM) Actions of 3 Children (first encounter, a subsequent encounter by a 1 and 2 year old, and a 4 year old) An Observational Study.

Action sequence	Action	Experience	Science Idea
Initial encounter Materials basic properties	Child1. Hit water surface	Exploring an unknown material	Force, properties of material
Exploring material	Child 2. dropped items near the water bowl into the water, bath duck, metal spoon, wooden play block , pebble, bath sponge .ping pong ball	Experience of properties	Floating and sinking, absorption in case of the sponge which gave out water when squeezed, Force,
Changing-control over material	Child 3 collected things he probably thought would float or sink and a small bottle with a lid.	Experimenting with items available, indicates some understanding of the properties of the material	Push, floating and sinking
Making something Using previous knowledge	Child 3 used a lid (like from toothpaste dispenser) to float as a boat, then filled with water and it sank.	Using previous experiential knowledge to fulfil child's planned objective	Forces, knowledge of properties of boats experimenting with sinking hollow open objects.

If a child is observed playing the stages though which they pass can be identified. A child may lose interest before reaching the end of the cycle, they may return later having had a 'think' or they may not return. However, using the sequence and provide an insight into a child's thinking and intuitive actions. The interactions follow a STEM Play Cycle similar to the one that occurs in inquiry science investigation in school.

16.5.2. Progression in STEM Interactions

Watching the same child as they develop and recording actions in each stage each time the stages can reveal progress. Photographing the stages and pasting them in a paper journal, or on line, can also provide a record of instances and progress, Referring back with the child a year later can provide insights through using this photo journal.

Identifying the stages in play has proved is particularly useful to parents and several CASTME (ICASE member) groups are using it as the CASTME play cycle and linking it with relevant photographs. Such can be a useful tool in assessment of the stages are numbered in sequence (Table 16. 2)

INSERT TABLE 16.2 here

Table 16. 2. The stages of the STEM Play Cycle tabulated for progression monitoring.

Play topic.	Date. Time
	Name of child.
Stage of STEM Play Cycle	Action of child in stage
1 Notices item - interest 'caught'	

2	Observes	
3	Explores. What does it do? What can I do?	
4	Actions. What happens?	
5	Tries more or loses interest and does something else. Leaves this STEM Play cycle	
6	Repeats actions, changes them.	
7	Remembers, stores for future application.	
8	Communicates	

16.5. The Voice of the Child.

As a biologist I observe, over time and most often visually. Such elicits questions. However, there are many genres of observations that can be made to learn about the child. The voice of the child is manifest in a number of ways. Thus, the play cycle approach whilst very useful and effective is not the sole way of understanding a child development of interests, skills and understanding Practitioners concerned with the development and achievement of the very young beginners of STEM experiences often employ other techniques in striving to 'hear' the child's voice, and not the voices of adults directing them. Recognising that combining different methods of listening to the child's 'voice' is encapsulated in the Mosaic approach (Clarke and Moss ,2001). The child's own voice can be 'listened' to by observing theory body language when they encounter different phenomena in of which some may interest the child, others not. Hence using such approaches the science actions and interactions can be observed.

So how can we tell they are interested and engaged? Tracking their path through any safe location can amplify this. In museum work tracking visitors yields similar information on what catches their attention. Asking children to tell you about what they're doing and why may yield some interesting information, taking hodographs of their activity, hearing their narrative as they play but talk out loud is informative and shows some interesting association in the child's mind of the actions and the object s/he is manipulating. A 2 year old's narrative reveals this. At a play session a two year old picked up the model female sheep, the ewe, and the model lamb. He put them side by side on the table. Then he rolled the ewe onto her back and said. "Now the baby can get his mother's milk and not be hungry". His mother, when we told her, said she was breastfeeding their new baby.

When they have the opportunity these very young children enjoy taking photographs on tablets and even mobile phones and will happily take them of their interests an, games and constructions. It is a particularly useful way of eliciting someone's interests as has been carried out in museums, zoos and botanical gardens and as many parents and practitioners employ this technique in monitoring and keeping records of the child's development. Such techniques reveal what is important to these children. Whilst there may be some commonality it is important to bear in mind the cultures within which these children are experiencing their world and reacting to. Such may be very different from that to which we are used. Our way is not necessarily better nor more appropriate, it suits us. The adult's role is observation, significant other, questioning, facilitating

Summary

- School science learning is but one contribution to a child's acquiring of a science fund of knowledge.
- Children have experienced science in action and interpreted scientific phenomena they have observed and experiences from their earliest years after birth as they develop into individuals Recognising that learners are experiencing
- Recognising the voice of the learner is important.
- Recognition by teachers that   Science and STEM in action from their earliest years is importan. Appreciating the knowledge and experiences that pupils bring to formal science learning.
- No longer do we assume these learners have no understanding or connection with the concepts of science lessons. Science is for all not only for science teachers to teach and it is their role to hear the child's understanding and work to link such with the accepted understanding that is taught.
- Such is easier said than done and requires not on subject knowledge but pedagogical skills.

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Biography

Sue Dale Tunnicliffe, part of ICASE since 1988, is a zoologist specialising in education. Her doctorate (King's College London) obtained after a teaching across all ages, set up and ran science and DT Advisory team for a London Authority, became Head of Education at the Zoological Society of London. Lectured in Winchester and Cambridge Universities before UCL IOE.   nd is Reader in Science education at UCL Institute of Education in London. She has published widely. She started ICASE pre secondary science and now is focusing on earliest years.