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Title: Science in Action in Spontaneous preschool play - an essential foundation for future understanding

Dr Sue Dale Tunnicliffe* & Dr Eirini Gkouskou**

*Reader in Science Education, UCL Institute of Education, London

**Senior Lecturer in Early Childhood and Education, UEL, London

Abstract

Children, like the young of many species, are born to play; it is the means by which young mammals acquire essential life skills From where do these practitioners of Science Technology, Engineering and Maths (STEM) acquire their understanding of their everyday world? Playing is an essential apprenticeship for developing (STEM) literacy. In the empirical tradition, observing children at their spontaneous play reveals that they are experiencing STEM in action, learning through thinking and doing, experience what happens if? Observing phenomena, asking questions, solving problems, designing investigations and ingeniously adapting what is available to use in these active Pre-speaking children, until they acquire verbal language for themselves, communicate by gestures and actions, observing and storing the experiences oyd.

We maintain, from our observational work, that children have various modes of play. Observations and Investigative play when they explore, plan, and do as well as evaluating the outcome and imaginative play where they replicate activities of adults that they have witnessed, such as dressing up as an adult, cooking in a make-believe kitchen, or, for example, composing and acting out a narrative in a mud kitchen. In all these activities children often compose their own narrative.

Humans have always been storytellers and telling young children stories is a key activity in their development and as a growing membership of their community. Communities tell stories to children; taduts read stoties to children. Hence children also learn about the world through listening and watching physical representations of these stories in often brightly coloured illustrations . In these representations of their everyday world children see representations on and in the media, which may be authentic representations or imaginary such as in cartoons, toys and pictorial fiction books. However, many enjoyable stories contain science information inadvertently and not written to accurately inform. Hence some understandings of the natural world are obtained which are incorrect, in fact mythical and there develops a conflict in the mind of the emergent scientist between myth and reality. This cognitive conflict begins to be resolved at about six years when children start being able to recognise myth as such, but the misinformation may linger.

Key words: early years science, play, emergent science, stories

Introduction

Science education has changed since the first half of the 19th century from a philosophy of providing for the privileged when the government decided to make provision for the elementary education of all children aged 5-13 creating a level of competency within the labouring classes, who had moved to cities with industry forsaking the land following the Industrial revolution, to enable them to be literate and numerate sufficient to work in industry. Such basic education was established in 1870 with the Forster Education Act. In the reconstructions of the United Kingdom after the Second World war great changes in education were implemented. The Education Act of 1944 implemented education for primary secondary tertiary aged learners but this act followed a number of education papers published during the war advocating three segments of secondary education, modern, technical and grammar. Change occurred again with the issuing of Government Circular 10/65 _The organisation of secondary education_. Thus, Comprehensive education was introduced but some selective schools remained. However, in the second half of the 20th Century it was increasingly recognised that Science teaching was not meeting the needs of many children and that primary children could also learn science. Hitherto Nature Study and nature tables had been a feature of elementary school rooms. More recently, a call has been made to encourage such learning and the reappearance of Nature tables , (Tomkins & Tunnicliffe, 2007). Indeed, such 'tables' using similar principles do occur is some primary schools as Discovery Tables, Bring and Share and class museums .

The Schools Council, the Nuffield Foundation and the Scottish Education Department (1967-1975) in the United Kingdom sponsored a series called Science 5-13. This included a series of activities which really helped primary teachers particularly, who were often under confident in their science knowledge, deliver competent lessons. These were not adapted from the secondary science curriculum but written focusing on everyday situations which illustrated concepts. (Tunnicliffe, 2015). In the second half of the 1980s the UK Government gave Educational Support Grants (ESG) which enabled local authorities in England to set up Advisory teachers to provide In-service training and hence continuous professions development (CPD) for primary teachers to enhance their understanding of science concepts and skills, and also introduce Design and Technology into primary schools. The creation of CPD is still needed for later initiatives and emphasis. As Clarke and Hollingsworth (2002) pointed out such needs to be continuous if it is to be effective. Professor Ros Driver and her colleagues suggested that a change in emphasis for science teaching style from declarative style to supporting learners through coactive instructions was beneficial to outcomes (Driver, Guesne.Tiberghien ,1983). Driver (2008) also challenged the establishment to recognise learners as active participants of science and that concrete experiences of 'doing' assisted them in concept development. She also said learners required teachers' support in helping them develop new ways of thinking about their activities. Moreover, she further ecognised that learners possess alternative frameworks, not misconceptions, which they develop from their experiences and thinking of explanations from what they knew (Driver et al. 1983). At the same time Osborne, Bell and Gilbert (1983) pointed out that children came to formal science teaching with their self-formulated children's science understanding which was developed in formal science education to school science.

More recently in the beginning of the 21st Centruy, Argumentation in science has become a critical aspect of science thinking in school science. It was first highlighted by Toulmin (1958; 2003) who proposed the argumentation structure. Such an approach applied to science learning requires the learners to develop and evaluate the argument and the higher order thinking skills of synthesis and evaluation (Osborne, Erduan & Simon, 2004).

The ability to make claims based on observable and empirical evidence and to be able to justify these claims and point out claims that do not have an evidential base are key aspects of science. Such an approach was developed by some primary educators of science in the 1980s (Tunnicliffe, 1990). Zimmerman (2007) looked at scientific thinking and reasoning skills by children in early years summarising the contribution of the research sector and concluded that the thinking skills of present science teaching are important in teaching approaches Monteira and Jimez-Aleixandre (2017) observed 5-6-year olds in Spanish Kindergarten over 5 months of a science investigation and concluded that these young children were able to ask questions, investigate, make meaningful observations, recognise the data from observations, interpret such and draw conclusions. In comparing, the actions of 3 to 4-year olds and the older, 5 to 6-year olds, these researchers noticed an increase in a child's ability in engaging in science processes developed with age (Monteria, Jinez-Aeixandre and Brocos,, 2018). The younger children were able to establish observations and some data but the older child was able to identify patterns from observation evaluate claims. They stress this cannot be generalised but was a developmental sequence observed and these children following the same longitudinal investigation of 5 months by having some teacher support. These researchers accepted the drawings of the children and simple word sentences from the children who could write asa= well as what they said in explanatory dialogue as evidence of entering the science process. Children's attitudes towards STEM are extremely important. These can influence their early attainment in the subject and their outlook in adulthood to scientific issues and their choice of later STEM study (Avraamidou, 2017) These young learners in the early years of schooling are particularly enthusiastic and enjoy practical experiments and independent investigation but this enthusiasm diminishes (Pell & Jarvis, 2010).

A twentieth first century development has been the increased recognition of early years preschool children do have the basic ability to consider the merits of evidence and possess an intrinsic understanding of finding out through experimenting. They worked with 4 and 5-year-old children. Bulenz (2013) worked with Kindergarten children who were 5 and 6 in Turkey to explore as to whether science instruction and play together increased understanding.

The realisation that the pre-formal education stages are important in establishing the foundations of learning has resulted in more research about this age group and the development of resources. The English Early Years Foundation Stage (EYFS) introduced by the UK Government sets standards for the learning, development and care of young child from birth to 5 years old. This EYFS curriculum was introduced in 2008 in England. In 2012, revised versions were issued and came into effect in September 2012 and at 2017, and the latest revised version is available (https://www.gov.uk/early-years-foundation-stage).

These curriculum requirements apply to all settings, not just schools that work with children from birth to five. It has 7 areas of which 'understanding the world' is particularly relevant to science content, where children are encourage to explore their own immediate environments and how these environments might vary from one another, as well as variations in living things and objects. Other areas such as literacy and numeracy, physical development, communication and language, personal and emotional development, and indeed art and design, all have a role in the development of fundamental science experiencers, no child can be or should be, isolated. Non-statutory guidance material provides people working in this area with the practice of an average child's abilities and expected involvement through these early years.

Learning progression is an area of interest to assessors as well as parents and teachers (Zimmerman, 2009). However, relatively little research on the scientific ideas that young children build has been hitherto reported. Allen and Kambouri-Danos (2017) suggested strategies connecting applicable developmental psychology research with that of educational research conducted with older children, suggesting learning progressions as a possible academic perspective for providing these links.

Imagination is an area of intellectual activity important to young children in particular (Egan, 1986). Picture books can develop some understanding of conceptual categories (Gelman & Waxman, 2009). Early years children in developed societies enjoy these brightly coloured, often-stylistic illustrations of fictional stories, frequently featuring certain plants or animals depicted in anthropomorphic ways for structure and behaviour. Such pictorial fiction books are a feature of pre formal school as well as many homes. Children, before they have mastered reading themselves, listen and look at the books as they are read to them and thus learn the sequence of a book. They recognise the characters and often can predict - once they have heard the story a few readings - what will happen next. Using pictorial fiction books reinforces teaching through the story and stimulates children's imagination whilst providing relevant opportunities to explore the real world (Egan, 1986). In some pictorial fiction book the stories often have a STEM focus. Work has particularly focused on those with a biological focus, albeit often inaccurate (Tunnicliffe & Bruguriere, 2017). Furthermore, we know that children can transfer fantastical characteristics to real animals (Ganea et al., 2004). We also know that learning through reading pictorial fiction books is affected by the manner of interaction between the adult and child during the reading (Mol & Bus, 2011).

Bruguiere and Tunnicliffe (2018) conclude that reading these stories of realistic fiction generates explanation-seeking curiosity but does not provide directly scientific explanations. However, the situation provides an opportunity for such but needs an informed adult to interpret the relevant content at an appropriate level for these emergent scientists to comprehend and discuss, drawing on the child's relevant experiences and listening to what they raise from associations. Such books allow children to indicate problems in the story but not to resolve it and should not stand-alone but are interpreted with accurate science learning. Growing amounts of research on aspects of pre-formal school play have been produced looking at various aspects. Much has been written on the acquisition of concepts but little on science learning (Lloyd, Downs, Crutchley, Edmonds and Paffard, 2016). Gopnik (2009) asserts that these early years children are intuitive scientists whilst Fleer (2000) conducted studies looking at practices promoting science underatdning with these children.

The starting point for science is observation (Sylva et al., 1980). As Tunnicliffe (2013 p.8) states, 'learning science is talking science' and the starting point for science is observation - adults working with children can share and talk about observations increasing their own self-esteem and confidence. Researchers may effectively theorise based on observations. There are for examples various categories of play which can be derived from either theory or observation. The California-based National Institute for Play (n.d.) describes seven play patterns:

1. Attunement play
2. Body play
3. Object play
4. Social play
5. Imaginative or pretend play
6. Storytelling play
7. Creative plays.

Like many of us who have observed children at play, Russell and McGuigan (2017, p.38) noticed that 'science specific' behaviours were evident during children's play and in other curriculum areas as well. Such behaviours included basic numeracy activities, as matching, recognising salient features having the same colour or shape, essential in science learning, particularly biological taxonomies, and aspects of dialogues when children ask themselves or voice aloud questions stimulated by their environment, and ponder what might happen if...? They were talking after they found out something, and talked about what did happen. Such activities are the foundation or pre-experiences on which formal science learning may be built in formal schooling (Gkouskou & Tunnicliffe, 2017). Russell and McGuigan (2016) summarised their thoughts about the links they perceive between what happens with some examples of observed behaviours, in a table, as an example of clustered threads and other links with emergent science. The three main headings were General Development, with threads of behaviour and links between threads, such as paying attention, naming and labeling concepts. The second relevant category was Science Enabling with examples gathered of concrete operational experiences, and hands on and use of multi-modality. Their example here was the provision of many 'science settings', particularly 'messy play' areas such as sand and water trays. The allowed for opportunities to observe changes in materials and how the learner could change and control materials and events. Their last of the three categories was Science specific, where the threads were explored and investigated for very early encounters with the situations. In some cases, these entailed recording and evaluating outcomes and simple forms of justifying or argumentation, generating practical outcomes such as electronic photographs, 3D histograms with blocks.

> If we fail our children and students in science, the reasons may include lack of appropriate experiences during early childhood (Roth, Goulart, Mafra and Plakitsi., 2013.p.14)

Play is the work of children and essential for intellectual achievement and emotional wellbeing (Whitbread, Basilio, Kuvalja and Verma., 2012). Some researchers consider there to be two aspects of play (Wood, cited in Robson, 2015). We term 'educational play' or 'freely chosen play' as spontaneous or free choice play.

Play has become an increasingly important area of research and recognition. Experience using cognitive and kinaesthetic skills is essential in learning and understanding science in the observable everyday context (Gkouskou & Tunnicliffe, 2017). From their earliest years children are hands-on intuitive scientists observing thinking and trying out things and observing the results, hence collecting and evaluating data. Such observations and investigations occur in everyday contexts, often unasked and are verbalised through hidden questions and statements. However, we believe that before practitioners should introduce specific activities targeted to introduced a particular scientific concept and skill, they should first establish which activities children in preschool or at home choose to do themselves, their free-choice learning, and identify the actions that illustrate basic scientific ideas - these are science in action (Gkouskou & Tunnicliffe, 2017). Gopnik (2009) documents the abilities of young preschool children and identifies these as intuitive scientists. Hence, we adopted a grounded theory approach and observed a variety of playgroups and children in their own home environments to observe what actions they carried out. Strikingly, they observed, thought through questions for themselves, even in verbal forms, children we could observe. Hence, we looked at free-choice play, guided to a certain extent in organised groups by the material put out for the children, but in their gardens and other play areas, including imaginative and role play in and outside. The research was carried out according to the British Education Research Association (2018) guidelines.

Methodology

We were interested in identifying science foundation experiences in play which we consider essential to understand before designing specific activities to assess a child's science development and competency. Grounded theory is a systematic methodology in the social sciences involving the construction of theory through methodical gathering and analysis of data. Grounded theory is a research methodology which operates inductively, in contrast to the hypothetico-deductive approach (Glaser, 2011). A study using grounded theory is likely to begin with a question, or even just with the collection of qualitative data. This is a method whereby the researcher collects data and then develops a means to analyse that data. It is often used in discourse analysis. In that form, dialogues are analysed for concepts.

Examples of children observing, playing with toys used, science actions, and experiencing basic concept such as pushing wheeled truck are given. For example, in the case of a child pushing a toy truck over smooth then a rough surface, the force is pushing. The child encountered friction when he had difficulties in physically pushing the truck over the rough surface but not over a smooth one. Two examples are presented at this section to demonstrate a further understanding of our research.

A two year-old boy who has some vocabulary looked at a mealworm on a table in a dish. 'Oh worm!' he said, 'It looks like a worm'. He meant earthworm. Mealworms are in fact the larval stage of a beetle but there is some superficial resemblance, so he used information he already held, specific features - in this case a segmented body longer than it was wide - to categorise the organism. This was an observation, matching what he saw to his mental model he held. It would come within a theme of 'naming', which is basic human instinct and indeed allocating a name- or label- to a concept is the last stage in concept acquisition (Bruner et al., 1956, p.5)

We observed the child's interpretation of the scene for potential involvement, his choice, the thinking that must have been present with resultant investigations and outcome. In particular a two year old boy in a Stay and Play centre (Lloyd et al, 2016) in an outside play area, brought to a morning session by his grandfather, chose two different small wheeled vehicle and ran round to the back of the small play side, climbed up to the platform. After positioning the two vehicles carefully at the top of the slide and letting them go at the same time, he rushed down and round to observe their descent and noted which arrived first at the end of the slide.

A group of five preschool children, three girls and two boys attending a private nursery in England participated in a free choice art activity. The age of the preschool children was from two years and five months till four years of age. The children were using coloured paper to create their art craft. A G1(four years old) observing a basket with fruit in the home corner, suggested to the rest of the team that they could to plant fruits. 'we will use the colourful paper as soil', she said and continued 'They will grow'. The rest of the children group agree while they picked up their favourite fruit they used a tray with colouredl paper reprensting soil. A B1 three years and seven months old) added to the conversation 'do not place them deep, as they will not come up'. The child tried to advise the group not to place the fruits deep as the pretend 'soil'- colourful paper because they will not grow. Finally, a G2 (three years and nine months old) added 'But we need water, plants do not grown without water'.
In this example the group of children demonstrate an emergent science understanding of a biological concept which developed from a free play activity and children iknterst 's initiative.

Two toddlers aged one year and nine months(A) and two years old (B) attending a private nursery in England are exploring Wooden Beads Around Intelligence game. Firstly, they present a coordination of movements while playing with the wooden beads. During the game they notice that the balls can be used in different paths to reach the top. They start exploring the possibility of the ball to reach the top by using different routes that the game offers. By demonstrating an understanding and using mostly gestures ,the toddlers came to a conclusion that the quickest way to reach the top is the straight line is. The toddlers A (one year and nine months) and B (two years old), through playing a game within with their physical development capability demonstrate an emergent scientific concept relevant with our analysis of activities in play (see Table 1.1)

The above were only two of the case studies explored during this research study whilst observing children. These case studies demonstrate the correlation of free play activities with the inherent scientific concepts.

We used the same approach of seeing 'what is'. What actions were taken at what concrete of otherwise situation, |using thematic analysis technique (Braun and Clarke, 2006), to read and reread our observations until themes emerged from the activities.

We made observations, in accordance with full ethical practices of the organisations or families who allowed us to observe (BERA, 2018). We made field notes on paper and took photographs of items the children chose to use .Eleven play groups in England were observed regularly over three years, ranging from a Church Mother and Toddler group to state run child care centres and nurseries.

Results

From our observations and field notes we identified the following main themes in spontaneous play in playgroups, not formal preschool settings. We observed spontaneous, free choice play in general and noted their choices and the way in children engaged in their play. This, we decided was the practice of science in its widest sense, embracing engineering and numeracy at times. We witnessed the beginnings of working scientifically, aspects of the nature of science. These are an instinctive part of the interactions of these emergent scientists with their environment and the things therein. We identified that there are two main categories of play activities.

- Play activities: children spontaneously choose the activity will be explored. Children play and act with it at the free choice activities. For the basic science experiences helpers need guidance link them with potential literacy, numeracy and social skills.
- Planned science activities: where children can investigate.

Our themes and analysis of main basic science ideas were compiled into a table (1.1) for the English Observations presented below where the activity, the scientific concept as well as the science in action are presented.

Activity	Scientific concepts	Science in action
Play in general	Nature of science	Observation, recognising data, recall of past experiences, analysis of issue, planning investigation, choosing what is needed, organising items, other children or adult, instructing, data gathering, recording, evaluation, reporting, communication, repeating investigations, changing variables. identifying patterns, and over time
Sand play	Forces, properties, feelings, mixtures, evaporation, friction, surfaces, materials	Filling, pouring, capacity, emptying, making tunnels, wet and dry sand.
Water Play	Mixing, currents, forces, gravity, ice- change of state, properties of water, absorption,	Using senses, hot, cold, tepid, Forces, gravity, buoyancy, measuring capacity, surface tension, light, colour, refraction,
Construction (emergent engineering)	Properties of materials, center of mass, stability, strength, energy, purpose, design, beams.	Making towers, bridges, homes for something, recognising shapes in buildings, fences, triangles, squares diagonals, rectangles, circles appropriate materials
Physical	Crawling, running jumping, rolling, Balancing, throwing, catching	How they move, what they use, what happens. • crawling through tunnels, on floor, running, chasing, sitting, dancing, hopping,

		jumping. Weather effects on body e.g. wind forces, slipping, heat, aching,
Malleable Materials	Forces used to change materials, properties of material, plasticity, joining.	Twisting, pressing, cutting shapes, modelling shapes, adhesion, play dough, pastry, paper, fabric, paper.
Cooking	Change of state, chemical reactions, effect of heat and cooling, heat transfers, evaporation, mass, measuring. Forces in cooking, pushes, pulls, gravity	Change of state, heating, melting, role of foods, origin of foods, sieving, mechanical mixing
Dolls, toy animals	Metamorphosis, development,	Caring, re-enacting child care, life cycles, carrying and pushing doll, talking and develop a sense of communication with it.
Construction	Centre of mass, stability, balance, shapes,tubes, beams, trfiabgles	Balancing, fixing pieces together, replication, drawing, painting, origami
Wheeled activities	Forces, push pull, twists, taut, friction, construction, gravity, speed acceleration, deceleration	Collecting items and carrying around
Role play		Simulating adult behavior and tasks, talking adult way of speaking, cooking, cleaning, shopping, organizing
Biology focused	Metamorphosis, classification, `Life cycles, adaption, habitats, ecosystems,	Grouping , Painting toy animals, identifying, recognising adaptations habitats, finding habitats for particular organisms. • How animals move • How self-moves, • How plants move, Parts of human body, same parts in animals, (knee of cat's back leg and human leg), parts of plants. Colours in nature, growing, seeds, fruits, foods what they eat and what are they biologically.
Outdoor Play	Light, shadows, weather, earth science	Soils, pebbles, stones, weather, rain, snow, hail, ice, appropriate clothing, sky, clouds, sun, recording weather, indicator species, variety of plants and particular habitats, clothes for weather Flight, pets, how animals move, behave. Effects of weather genres on

		environment
Mud play	Forces, mixing, properties	As above and Role play
Climbing frames	Forces, muscle powered, actions, balance	Risk estimate, energy, climbing, hand eye, coordination.
Slides	Gravity, friction, rates of descent with different loads, artefacts	Using slide, decreasing their friction by sitting on mat running up, running down wheeled vehicles, different sizes and loads, rolling balls down.
Ball games	Forces, pendulum, centrifugal forces, co-ordination, speed,	Bat and ball, ball on string, yo yos.
Numeracy	Measuring forces, volumes, mass	Counting, matching, shapes, pouring an amount quantity, measuring an amount
Literacy	Listen to stories, identifying images, matching, speaking, and making symbols, writing. Drawing to communicate Predicting outcomes, recognising myths and reality, critical thinking, reasoning.	Orientation of using a book, recognising symbols Linking illustrations to text Interpreting illustrations Identifying problem, solving story issue Critiquing, redesign myth and reality predicting next event, scale

1.1 Table: Early Years Science (STEM) Actions and Skills in Play (Western)

The Table 1.1 represents the observed activity which took place as well as the scientific concept and the science in action. Via this thematic analysis it is obvious that there are scientific concepts as well as science in action demonstrated by the play activities documented.

There is some literature focused on kindergarten children and science but most begins with considering relevant aspects of science learning in children of 5 years of age and in foram educational set up.. We consider that this table can be used as an educational tool where the pre-formal school practitioners could note which play activities children spontaneously choose. Is there a difference between disadvantaged (establish by pupil premium) and non-disadvantaged, children in their approach in their spontaneous investigations? What do children play with and actions with it, of free choice and what is the basic science experiences they explore. Taking into consideration that personnel, of whatever genre, need guidance on this and further links to literacy, numeracy and social skills to be able to observe, record, evaluate and report on a learner's potential.

We believe that, if we as practitioners, along with other practitioners, are able to recognise the science (STEM) in action in free choice play activities they, in formal or informal, situations may be able to develop as appropriate an awareness in these emergent scientists. Furthermore, identification of such basic concepts in action activities may provide confidence to the many personnel in early years who do not have an identity, (Avraamidou, 2017) or confidence in their scientific knowledge. Moreover, communication and social skills are apparent as children develop in their play.

Conclusion

The starting point for the learning of science, at this early age, is play. Bottrill (2018) states that play is one of the most misunderstood concepts. The diverse and important functions of play have made a focus of interest on how children learn and how play can be deployed to augment other modes of learning (Wells, 2015). In such activities these early learners are making observations, asking questions and problem solving, albeit to themselves, devising their own strategies for eliciting an answer. Such working out by the children are them using 'hidden questions' to themselves even though in the earliest of years, thoughts are not verbalised. Thus, the only evidence, we, as, observers, have is the the actions of children which we can observe. These are an expressed models of their thoughts expressed in this action science play, answering their own questions, through - investigating, trying out actions and experiencing the outcomes. These learning instances occur in the immediate environment of the child, in its community, with the people with whom children spend their time. This STEM in action instigated by the learner themselves begins long before any formal educational interaction. Enabling children on their path in learning is a community endeavor. These places of potential learning, where they live and their immediate environment of inside and outside are the world which they explore. In these locations in a landscape formed through earth science actions, children witness everyday activities and phenomena, such as cooking, cleaning, washing, various activities with materials such as textiles, wood, clay, as well as identifying , weather and climate. These learners are involved with their own basic life processes such as moving, breathing, eating, excreting which they experience in themselves. They encounter and begin noticing the biodiversity of their living world. They observe and are involved in the human activities associated with the life processes and beyond. They experience physics in action and the earth science, landscapes, weather as well as their environmental landscape.

Children are immersed in their environment, to include natural structures various amounts of technology, maths and science. Thus, can range from a simple cooking vessel being used on an open fire to mobile phones; from natural vegetation to a manicured garden and the everyday non-built areas. Moreover, the natural environment is comprised from physical, geological and biological matter and features of this, such as rocks, plants and watercourses may be observed. Additionally, the culture and particular uses of science and technology by the community with whom the children live are evident and noticed, pointed out by members of the community, buildings, transport, water sources for instance. If children cannot spontaneously play can they develop as scientifically literate beings, problem solvers, communicators?

References

Allen, M. & Kambouri-Danos, M. (2017) Substantive conceptual development in preschool science: contemporary issues and future directions, *Early Child Development and Care,* 187:2, 181-191, DOI: 10.1080/03004430.2016.1237561

Avraamidou (2017) *Stories we Live, Identities we Build. Elementary Science Identity as a Lived Experience.* Talk given NARST San Antonio, USA.

Bottrill, G. (2018). *Can I go and play now? Rethinking the early Years*. Sage, London.

Braun, V. and Clarke, V. (2006) Using thematic analysis in psychol ...

eprints.uwe.ac.uk/11735/2/thematic_analysis_revised_-_final.pdf

Braun, *V*. and *Clarke*, *V*. (*2006*) *Using thematic analysis* in psychology. *Qualitative Research* in *Psychology*, *3* (*2*). *pp*. *77-101*. ISSN. 1478-0887 Available from: ...
Using thematic analysis in psychology: Qualitative Research in ...
www.tandfonline.com/doi/abs/10.1191/1478088706qp063oa
Volume *3*, *2006* - Issue *2* ...
Braun, V. and Clarke V. (2008).*Using Thematic Analysis in Psychology)*
https://www.researchgate.net/.../235356393_ ...

Braun, V and Clarke, V. (*2006*) Using thematic analysis in psychology. *Qualitative Research* in *Psychology* *3* (*2*). *pp*. *77-101*

Bruner, J. S., J. J. Goodnow, and G. A. Austin. 1956. *A Study of Thinking*. New York: John Wiley.

Clarke, D. and Hollingsworth, H. (2002). Elaborating a model of teacher professional growth. *Teaching & Teacher Education* 18(8), 947-967.

Driver, R., Guesne, E., and Tiberghien, A. (Eds) (1985). *Children's Ideas in Science*. Milton Keynes, Open University Press.

Driver, R. (2008) *The Pupil as Scientist?* Open University Press: Maidenhead UK

Erduran, S., Simon, S. and Osborne, J. (2004). 'Taping into argumentation: Developments in the application of Toulmin's Argument Pattern for studying science discourse'. *Science Education* 88 (6), 915- 933.

Gillard D (2018) *Education in England: a history* www.educationengland.org.uk/history

Ganea et al. (2004) Transfer between Picture Books and the Real World by Very Young Children, *Journal of Cognition and Development,* 9 (1) , 46-66

Glaser, B. (2011) *Getting out of the data: Grounded theory conceptualisation*. Mill Valley, CA. Sociology Press.

Gkouskou, E. and Tunnicliffe, S. (2017). Natural History Dioramas: An opportunity for children to observe physical Science in action in a moment of time. *Science Education International*. 28(2), 7-18.

Howe, A. and Davis, D. P.(2005) in Ed. J. Moyles, *The Excellence of Play*. second edition OUP. page. 128

Lloyd, E. Edmonds, C., Downs, C., Crutchley, R. & Paffard, F. (2017) Talking everyday science to very young children: a study involving parents and practitioners within an early childhood centre, *Early Child Development and Care*,187:2, 244-260, DOI: 10.1080/03004430.2016.1226355

Moyles, J. (1989) *Just Playing? The Role and Status of Play in Early Childhood Education.* Maidenhead. Open University Press.

Monteira, S.F and Jiménez-Aleixandre, J.P. (2016) The Practice of using evidence in kindergarten: The role of purposeful observation. *Journal of Research in Science Teaching* 53 (8) 1232-1258

Monteira, S.F, Jiménez-Aleixandre, J.P, Brocos, P., (2018) *Use of Evidence by 3-4 and 5-6 year-olds: a comparative study*. Talk given at European Research in Didactics of Biology, (ERIDOB), July 4. Zaragoza, Spain

National Institute for Play (n.d.). The Science. Pattern of play. Retrieved from www.nifplay.org/science/pattern-play/.

Osborne, R.J., Bell, B.F &. Gilbert, J.K (1983) Science teaching and children's views of the world, *European Journal of Science Education*, 5:1, 1-14, DOI:10.1080/0140528830050101

Pell, T. & Jarvis, T. (2010). Developing attitude to science scales for use with children of ages from five to eleven years. *International Journal of Science Education* 23(8),847-862.

Piekney, J. Grube, D., and Maehler, C. (2013) The Development of Experimentation and Evidence Evaluation Skills at pre School Age. *International journal of Science Education.* DOI:10.1080/09500693.2013.776192

Roth,Wolff-Michael Goulart, Maria Ines Mafra, Plakitsi, K.(2013). *Science Education during Early Childhood. A cultural – historical Perspective*. Dordrecht, Springer p.14

Russell, T and McGuigan, L. (2016) *Exploring Science with Young Children . A developmental perspective.* London Sage Table of themes, page 39

Sylva, K., Roy, C., and Painter, M. (1980) *Child watching at Playgroup and nursery*

Toulmin, S.E. (1958). *The uses of Argument.* Cambridge University Press. Cambridge

Toulmin, S.E. (2003). *The uses of Argument* (Updated edition). Cambridge University Press. Cambridge

Tunnicliffe, S. D. (2013) *Talking and Doing Science in the Early Years* Routledge London

Tunnicliffe, S.D and Brugueiere, C. (2017) Growing scientific Thinking with fictional ; books: Questioning and imagination in Early Years, in (Eds) M.F.Martins Costa and C.P. J.B.V. Dorrio, *Hands on Science: Growing with Science* p. 16-19

Tunnicliffe S. D. (1990) *Challenge Science - Living Things pupil material and teachers book.* Basil Blackwell. Oxford

Whitebread, D., Basilio, M., Kuvalja, M. & Verma, M. (2012). *The importance of play: a report on the value of children's play with a series of policy recommendations*. Brussels, Belgium: Toys Industries for Europe.

Wood, E. (2015) Wonder why our dog has been so naughty? Chapter 2 in (eds) Sue Robson and Suzanne Flannery Quinn .*The Routledge International Handbook of Young Children's Thinking and Understanding*, Routledge, Abingdon, UK

Zimmerman, C. (2007) The Development of scientific thinking skills in elementary and middle school. *Developmental Review*, 27, 172-223

Zimmmerman, C. (2017) The Development and Validation of a Learning Progression for Argumentation. *Science Report* **53, (6),** 821-846.ww.nifplay.org/science/pattern-play/retrieved 27/6/18