Chapter 18
Science in Early Learning Centres: Satisfying Curiosity, Guided Play or Lost Opportunities?

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18.1 Introduction

With limited research into emergent science skills and a lack of classroom-based research to investigate young children's thinking of scientific concepts (Fleer 2006; Fleer and Robbins 2003; Venville et al. 2003), it is generally unknown how very young children process their scientific curiosity into knowledge. Johnston (2009, p. 2511) explains that important factors affecting the development of scientific skills are found to be in a combination of context and social interactions between individuals, peers and adults. Johnston (2009, p. 2512) also asserts that development of learning specific skills such as observation skills should be supported by focused and structured teaching. Advancing these skills also call on a child's prior experience which are enhanced by using the senses associated with touch, smell, sight, sound and taste. Becoming skilled in observation leads to other scientific skills such as classification, explanation and prediction. By using an integrated curriculum and insightful questioning, educators can present opportunities for children to transform their ideas and rethink what they observe by placing a different perspective on an investigation. New possibilities can be created, and exciting connections made between people and the learning environment when alternative methods of exploring an idea are presented or discovered.

Children, according to O'Sullivan-Smyser (1996, p. 20), are wise about their own learning as they 'seem to know instinctively how to acquire information at a

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level that is useful to them'. A major premise to this is an educators' belief that from birth a child is biologically predisposed to relating to and learning from others (Millikin 2003). Therefore, in developing scientific concepts, children often need adult assistance to advance complex thoughts and understand why things are the way they are and why things work the way they do. Young children also require a battery of experiences that allow them to freely explore a concept and move their understandings to more refined knowledge, usually with the assistance of others. What children pay attention to is determined by the environment provided, freedom to explore and what adults or significant others in their company point out to them (Fleer 2007). Steps to encourage and develop scientific thinking should therefore be undertaken by significant others such as teachers, caregivers and parents who have a social and cultural awareness of a child's background and prior learning experiences.

This chapter presents a window into the teaching and learning practices of science concepts for young children in early learning centres, describing both positive experiences and lost opportunities for the development of emergent science skills. The first part of the chapter introduces a socio-cultural context for learning and the notion of a zone of proximal development as a theoretical framework. In the second part of this chapter, the research design and the findings are presented.

18.1.1 A Socio-cultural Context for Learning

Generally, learning environments are made up of social and cultural factors that represent the personal, environmental, interpersonal and contextual influences on a person (Robbins 2005). Children integrate their experiences and curiosity, with the guidance of others, to build new understandings about their world and its workings. Adults who pay attention to how the child's involvement changes and transforms as he or she participates in experiences (Robbins 2005) assist learning and conceptual understanding within a social-cultural context. A social-cultural context recognises prior learning and provides connections and social interaction between individual cognitive thought and actions and those of a group (Venville et al. 2003; Robbins 2005; Fleer and Robbins 2003; Rogoff 2003). The relationship between cognitive and emotional areas of development contributes to and benefits the socio-cultural perspective where social practices rather than individual actions are central to the structure of cognition (Robbins 2005).

The abilities to think logically and sequentially to solve problems in a safe and encouraging environment are essential skills which are honed through engagement with others and opportunities to practise them. 'Thinking is embedded in socio-cultural contexts, and reflects local practices, beliefs, values and goals' (Robbins 2008, p. 27). When teachers are aware of a child's prior learning and include new experiences in a learning environment that could extend their knowledge, an opportunity is provided to make connections between the old and the new knowledge, thus advancing intellect. A child's interpersonal and contextual influences on intellectual learning are clarified and developed when individual thoughts are positively influenced by others in their environment (Robbins 2008). However, cognitive development is not just thinking. It includes a wide range of mental behaviours such as remembering, concentrating, perceiving, reasoning and problem solving (Szarkowicz 2006). Moving a child's conceptual understanding to a new level occurs when he or she is actively engaged and feels confident with new information.

18.1.2 The Zone of Proximal Development

The space between the known and the capability of adding new knowledge is described by Vygotsky (Millikin 2003) as the Zone of Proximal Development (ZPD). Fleer (2006) described this space as 'hypothetical' and elaborated that it is the distance between a child's actual developmental level and their potential level of development. Motivation and social influences by others can assist a child to realise potential. Millikin (2003) concurred that the value and influences of social interaction and feedback from interpersonal and intrapersonal connections advances a child's potential development with the help of adults. Mulaguzzi (1998), however, urges caution with a model where adult intervention is relied upon to develop a child's potential learning. He feels it could result in a return to traditional teaching where words and answers are provided rather than a supportive environment where play, listening and respect for a child's wonder is acknowledged. Robbins (2005, p. 152) supports Mulaguzzi's concern and warns about the dangers of 'preconceived ideas of what children know and can do'.

The aim of teaching, according to Piaget (Mulaguzzi 1998), is to provide conditions for learning that require adults to understand that children are producers, not just consumers, of knowledge and culture. Rinaldi (2005) insists that time and understanding are also essential ingredients for successful learning and adds that adults should only guide a child's learning and ensure enough time is provided to listen to and model effective skills. Rinaldi considers respectful listening skills legitimates another's point of view and can assist a child's understanding of new concepts. Millikin (2003) and Robbins (2005) agree that a socio-cultural context affects the role of the learner and the educator, when children's own questions and theories are thoughtfully considered and negotiated with others. This then supports new learning, consolidates what is known and prepares the child for new experiences. Involvement in investigative events or activities, which move a child from known experiences to new experiences, in an environment where adults assist the advancement of cognitive development rather than providing answers, has the makings of a rich learning environment.

18.1.3 Early Learning Centres

An early learning centre (ELC) is a place where adults and young children come together to exchange knowledge in defined surroundings. These centres can cater for children from birth to 8 years of age and are defined in many ways: child care centres, playgroup, pre-kindy, kindergarten, pre-primary and school years 1–3. A progressive ELC recognises the rights of a child and is attuned to each child's welfare. Simply having aesthetically stimulating environments and educators to provide answers is insufficient in an ELC as children need to be actively engaged in their learning. In a socio-cultural setting where the environment and community are at one with children's needs, adults can provide a semi-structured environment that enables children to communicate, participate and make meaning of their surroundings (Fleer and Robbins 2003). Young children therefore require an ELC where the context is conducive to guided and investigative play and where an interested adult is on hand to assist their constructive thinking so that new concepts are expanded and built upon.

Playgroups serve to connect families within a community. They are informal groups usually led by parents and set up as a community entity, supported by local governments. Attending children are accompanied by an adult (usually a parent or guardian) and meet weekly in a relaxed environment. Children may attend playgroup from birth to 5 years of age with a view of developing social skills, to play and forge friendships.

18.1.4 Research Questions

The following research questions will be addressed in this paper.

1. What opportunities are provided for young children to become engaged in scientific inquiry in early learning centres?
2. In what way do opportunities presented in early learning centres benefit the development of scientific concepts for young children?

18.2 Methodology

The overall purpose of this qualitative research was to gain knowledge of opportunities provided for young children to participate in science in early learning centres. In order to gain this information, a flexible and patient method of inquiry was required to accommodate the unpredictable behaviour that children of this age can present. To achieve this method and generate an understanding of how science is developed and represented in ELCs, a multiple case study research design was used. Multiple case studies allow researchers to better understand the complexity, context and depth of situations, while providing intensive, holistic descriptions and analyses of these situations (Yin 2003).

18.2.1 Settings: Early Learning Centres

Three diverse ELCs were used as the settings for this research. An overview of each ELC can be found in Table 18.1. In each ELC, children directly involved in this research were observed as they engaged in daily activities. Some of the activities were related directly to scientific inquiry. Different physical and institutional teaching and learning contexts were presented in each centre. Two of the three centres (ELC1 and ELC2) were pre-kindergarten classes. These pre-kindergarten classes were attached to larger schools and supported by a Christian religious sector. The third centre (ELC3) was a local government non-sector community playgroup, run by parents. Parents of children in ELC1 and ELC2 contributed fees to the schools so their child(ren) could attend pre-kindergarten. At ELC3, parents contributed to a managed fund that covered the costs of day-to-day running of the centre.

18.2.2 Educators

In each pre-kindergarten (ELC1 and ELC2), a qualified teacher was assisted by a trained education assistant (EA). EAs, under teacher direction, attend to the children's emotional and social needs and assist the preparation of lessons and the classroom. In the playgroup (ELC3), parents help each other in the physical set-up of the learning areas and take responsibility for their own child's welfare.

Teachers (ELC1 and ELC2) were interviewed separately to find whether or not they thought science an important part of the ELC curriculum and to find their levels of confidence and experience in teaching science concepts to young children. Parents were engaged in casual conversations in all three learning centres where their opinion about the value of science teaching and learning was sought.

The teacher in ELC1 was trained to teach at primary school, and her 15 years' teaching experience was mostly in kindergarten and pre-primary classrooms. She was confident to teach science and thoroughly enjoyed teaching young children. Her rich educational background included teaching in Australia and overseas. Currently, she felt restricted by political pressure to 'push-down' the curriculum which she believed would restrict children's time for discovery learning.

The teacher in ELC2 was also trained to teach primary school. In her 12 years of teaching experience, she had taught a number of different primary year levels, five of which were in Year 1 and pre-primary classrooms. This educator's science experience teaching was in primary school years above Year 1. She did not feel confident teaching science and recalled only having learnt how to teach science to upper primary students when at university. She did not specifically seek professional development to teach early childhood science as she did not consider the subject to be an important part of the pre-kindergarten curriculum.

Table 18.1 An overview of the three early learning centres

Description	ELC1	ELC2	ELC3
Institution	Independent PK-Yr 12 school	PK-Yr 6 primary school	Local government community playgroup
Days children attended	4 × ½ days per week	4 × ½ days per week	1 × 2 h per week
School population	>1,000	~250	~19
Group observed and ages	Pre-kindergarten 20 × 3 and 4 year old	Pre-kindergarten 15 × 3 and 4 year old	Playgroup: up to 20 from 3 months to 4-year-olds
Educators	Teacher plus one education assistant	Teacher plus one education assistant	Parents
Training and experience of teacher and education assistant (EA)	Primary trained with ECE units 15 years ECE EA: qualified	Primary trained, some ECE units limited ECE experience EA: qualified	Fully parent-assisted programme No specific training or experience discussed with researcher
Gender	Boys and girls	Boys and girls	Boys and girls
Specific science offered	Daily	Special occasions	Incidental learning
Parent involvement in class	Minimal – could choose to participate on rostered help. Fathers and mothers involved	Invited to start day with child and help him/her settle. Mothers and grandmothers attended. Roster being developed	Total involvement by mothers
Data collection	Fourth term 2008	First term 2009	Third term 2008

ECE early childhood education

Being a playgroup, there was no main teacher in ELC3. A parent, who was trained as an English as a second-language teacher, participated in an interview and suggested that as science was a part of 'nearly everything we do, it should be a part of what the kids do in kindergarten and every other year at school'. Yet, another parent offered that she did not see the relevance in this research as 'these children are too young to do science'. She thought science could be 'dangerous and was really a high school subject'.

As the study progressed, it became clear to the researcher that considering whether or not science was an important part of an ELC was something not previously discussed by any of the centre's communities.

18.2.3 Data Collection

Being thoroughly familiar with the detail of the context in which data would be collected was an essential starting point to find what opportunities were provided for children to become engaged in scientific inquiry and how these opportunities benefited the teaching and learning of science for young children. Each ELC was visited once a week and over the period of one school term, during the centre's morning session. Visits were designed to collect data through conversations with children, parents and teachers; record and conduct casual interviews with teachers; obtain work samples from children; take photographs if permitted; and make field notes of observations so that a clear picture of children's engagement in scientific activities could be formed.

The research was conducted in four stages in each ELC: (1) pre-research, (2) initial visit, (3) subsequent visits and (4) post-data collection. In the pre-research stage, contact was made with each ELC to determine a willingness to participate. Once agreement to participate was attained, approval was sought and gained from the principal of each of the three centres. In the initial visit stage, the researcher discussed details and implications of the research with classroom teachers. Parents were informed and children approached for permission to observe their scientific investigations. Booklets containing ethical implications, information on the research and consent forms, for both teachers and parents, were then delivered to each ELC for signatures of consent. In subsequent visits, the researcher became familiar with the context of the ELC. Interrelationships between children and adults, children and other children were observed and noted along with teachers' and children's interactions with the resources used within the physical and socio-cultural environment. So that children in the centre became familiar with the researcher's presence, a participant-observer role was engaged by joining in activities and, where appropriate, assisting the teacher. This strategy strengthened the relationship within the centre and with children. Planned visits ensured adequate time was available to obtain detailed observations and conversations with children and teachers. Where permitted, photographs and children's drawings were added to data collected. Post-data collection involved a return visit to the ELC to share photographs and initial findings.

18.2.4 Construction and Interpretation of Case Studies

To illustrate the range of science teaching and learning opportunities within the ELCs, three case studies were developed. Each case study was constructed with a general introduction to provide the context, a short vignette to capture the science learning available to the young children and an interpretation. Each vignette incorporated sufficient detail to provide authenticity and captured the action and interaction of the children within their environment in a vivid and life-like manner (Wildy 1999). Interpretation of the vignettes related to the science learning present and opportunities that could have been presented within each ELC.

18.3 Findings

The three case studies entitled *Satisfying curiosity*, *Guided play* and *Lost opportunities* are presented to elaborate findings.

18.3.1 *Case Study 1: Satisfying Curiosity*

18.3.1.1 Introduction

This case study was taken from the community playgroup (ELC3) and features a three-and-a-half-year-old boy who will be called Skater Boy. Skater Boy is confident in the setting, knows all the parents and children who attend the playgroup and is familiar with its routines and resources. Children in this playgroup are able to play freely and direct their own experiences.

18.3.1.2 Vignette

Skater Boy announced to no one in particular that he was going to make a skateboard. He noticed the researcher was close by and mentioned, without direct contact, his plan to make the skateboard. He collected one rectangular and two cylindrical 3D wooden building blocks from the block box and placed the cylinders under the rectangle. ‘These are rollers’, he said out loud. He tested his design and found the original prototype unsuccessful, so went back to the block collection, found another cylinder and added it to his skateboard (see Fig. 18.1). ‘There’s three now’, Skater Boy said to himself. The new model was tested, but again the result was not acceptable (see Fig. 18.2), so he retrieved more wooden cylinders to act as rollers.

For each new design, Skater Boy patiently added just one more cylinder, counted them (see Fig. 18.3), then tested his skateboard by standing on it. With each trial, the cylinders rolled out from under the rectangle. Skater Boy then moved his testing to include holding onto a cupboard for stability (see Fig. 18.4). During construction, he continually chatted away to himself counting cylinders, planning his next move, testing, thinking out loud and trying to gain balance.

Skater Boy displayed no frustration with the unsuccessful trials but did engage the researcher in his conversation from time to time:

Skater Boy: It’s not working.
Researcher: Why isn’t it working?
Skater Boy: It needs more rollers.
Skater Boy: Look there’s five of ‘em.

Finally, Skater Boy announced, ‘There’s no room left. It’d better work’. Carefully, Skater Boy stood on the rectangle covering the five cylinders, again hanging onto the cupboard to help his balance, he discovered that his construction felt more stable. His smile indicated he was happy with this result. He then let go of the support, bent his knees and momentarily balanced on his skateboard. In a celebratory salute, he held his arms aloft before he felt the skateboard start to topple and had to jump off.

Skater Boy: Did you see? Did you see it? It worked. Good!

Fig. 18.1 Skater Boy modifies the prototype

Fig. 18.2 Testing the new model

Skater Boy then disassembled his skateboard, threw the pieces he had used back in the block box and disappeared into another room without further comment.

18.3.1.3 Interpretation

Skater Boy told the story of his skateboard without prompting, and communicated using egocentric speech or 'self-talk' during the activity. His curiosity had been

Fig. 18.3 Counting extra rollers

Fig. 18.4 Using support during a test

aroused after watching older boys playing with skateboards in a car park. Within his unstructured play space, Skater Boy was able to test his curiosity by designing and making his own version of a skateboard.

Beginning with self interest, Skater Boy constructed a plan in his mind, talked his thoughts through, gathered components, tested his ideas and redesigned them until he was satisfied with the results. Skater Boy had unwittingly used the plan to make, test, appraise scheme of technology development that saw him redesign his skateboard again and again until he was satisfied. Skater Boy was confident that a cylinder would roll but never articulated the name of the shape. And, although he did not use the word 'balance' in his dialogue, it was clear he was aware of the scientific concept of balance. This was demonstrated through actions of jumping off the construction when it felt unstable, by recognising a need to hold the cupboard to help adjust stability and by demonstrating balance when he controlled his stance on the construction.

Consolidation and transference of prior learning was demonstrated as Skater Boy included the mathematical concept of one to one correspondence, verbally counting and adding on. Socially, he worked alone. When other children came close, he shielded his work and made it clear (in a non-threatening way) this was his territory. From observed actions, it is suggested that Skater Boy also demonstrated creativity, confidence, concentration, sustained interest and determination as his individual approach satisfied his self-interest and needs at this stage of his development. Had intervention been provided, he may have lost interest or been persuaded to change his plan. Either way, he would not have achieved his personal goal and the obvious satisfaction brought about by achievement. As an unsolicited engineering activity and self-motivated concept, Skater Boy exposed clear thought processes, scientific investigation and concepts of balance. Without assistance, this young boy took himself into a ZPD as he engaged the complex higher-order thinking skills required to modify and retest his design until product satisfaction was achieved. His self-talk helped him plan the sequence of his invention and clarify his ideas. Later in the morning, Skater Boy was noticed building a ramp for his skate board, illustrating that he was once again transferring past learning to that of a new project.

18.3.2 Case Study 2: Guided Play

18.3.2.1 Introduction

The researcher was on her third visit to ELC2, where children had only been attending the centre for 6 weeks. Nature Boy and Nature Girl were the focus of the observations in ELC2. Both children were three and a half years old. Nature Boy and Nature Girl were confident and cooperative children who enjoyed being the centre of attention in the class.

The ELC was set up so that during ‘free-play time’, the children could move about at will, thread beads, do puzzles that were placed on tables or on the floor, colour in pictures and draw on paper. A wooden train set with magnetic points was placed in the middle of the floor with which the children could play. A folding book case housed a selection of picture books in the reading corner. The home corner consisted of a cupboard with cups, tea, coffee, sugar and milk containers, a table and two chairs, a low rail with dress-ups on hangers, some hats and cardboard crowns on top of the hanger and a vase of feathers. Noticeably, there were no curiosity tables containing items of interest to investigate during the first few weeks of the research in ELC2.

During free play, confident children flittered about from table to table, while the more immature children tended to stand and watch other children play. As much as they were encouraged to go to activities, they seemed unsure about what to do and did not spend this free-play time engaged in any activity in depth.

18.3.2.2 Vignette

A table set-up with a variety of natural products, such as various seed pods, leaves, bark and a bird's nest, was added to the classroom for children to freely explore if they wished. When parents arrived at school, they took their children to this new exhibit, modelled curiosity and pointed out features of the leaves and pods to their children. However, nothing was touched. Later, during the free-play time, the researcher stayed at that nature table to encourage investigation. Although children were slightly curious, they were not keen to touch or play with these natural items, which they described as 'dirty' and 'not toys'.

Nature Boy and Nature Girl were invited to participate in a guided investigation of a variety of seeds pods with the researcher, while the other children joined the teacher on the mat. After a discussion about seed pods, the children were encouraged to use their senses to find differences between a gum nut and a pine cone. Nature Boy and Nature Girl participated but showed little initial interest in the objects. Next, it was suggested to sort the seeds pods into two groups: big seed pods and small seed pods (see Fig. 18.5). Once big seed pods were separated from small seed pods according to their own definition of 'small' and 'big', the children were asked to reclassify one of these groups using the same criteria: big and small (see Fig. 18.6).

The children were then left to make their own classifications. Nature Boy decided to put all the pods with 'sharp' edges into a group (see Fig. 18.7), while Nature Girl sorted pine cones from all the other seed pods (see Fig. 18.8).

Rather than returning to the mat for the next session, Nature Boy and Nature Girl remained at the table to continue sorting according to their own rules. With freedom to play, they involved imagination to manipulate objects and extended their classification skills. Nature Boy put leaves end to end to represent the outline of a track for his 'train' to travel along, while Nature Girl imagined palm bark to be a boat and sailed it on an imaginary sea of leaves.

18.3.2.3 Interpretation

As a result of guided play, these children were able to classify objects using observational skills and extended their learning by creating personal classifications and renaming objects that exposed their prior experiences related to trains and boats. Additionally, once the children became 'lost in their play', the researcher noted their actions displayed persistence, humour, curiosity and communication. Nature Boy and Nature Girl had formed a positive relationship as they jointly discussed possibilities and extended knowledge while engaged in 'giggling' play. Confidence and sustained shared thinking were exhibited as they handled and classified the natural objects they had earlier rejected. Adult assistance respectfully supported the children's learning helping them to focus their attention and expose a ZPD. As such, the children extended their ability to stay on task and gain skills of perseverance and concentration enabling them to acquire new knowledge such as that associated with the skill of classification. Guided play helped Nature Boy and Nature girl overcome

Fig. 18.5 Nature Boy compares the size of pods

Fig. 18.6 Nature Girl reclassifies the pods

their initial fear. Offered in a supportive and deliberate way, guidance also encouraged them to solve problems by making critical choices and discover the value of their personal observational skills.

Initially, the young children in this centre displayed shallow engagement as they skimmed the surface of a variety of activities offered to engage their learning. Given they had only been attending ELC2 for 6 weeks, it was not unusual to see some of the children struggling to settle into a routine and become distracted in their new environment. This pre-kindergarten group was unaccustomed to classroom rules, the structure, resources and adults attached to this centre. The children required nurturing, one-on-one attention, small group activities and time to become acquainted with their socio-cultural context before they could comfortably form new relationships

Fig. 18.7 Nature Boy sorts pods with sharp edges from smooth pods

Fig. 18.8 Nature Girl sorts pine cones from other objects

and enhance their academic intelligence. This process was applied with Nature Boy and Nature Girl as they employed a scientific investigation.

According to Fleer (2007), if children are to gain the most of a playful context for learning, they require adult mediation in order to pay attention to the scientific opportunities being offered. Using guided play as pedagogy, the scientific skills of observation, classification, problem solving, creativity and critical choice, considered highly important in emergent science, were well served.

18.3.3 Case Study 3: Lost Opportunities

18.3.3.1 Introduction

A small room within ELC1 had been prepared for this corn-popping experience. All furnishings had been removed, and in the centre of the room an electric fry-pan had been placed in the middle of a circular carpet of paper. Children were assembled as they arrived at school in another area and told about the science investigation. Curiosity was running high as the eager children were given instructions to sit around the edge of the paper and not to touch the cord. The EA was sitting with the pan to ensure children kept a safe distance.

18.3.3.2 Vignette

Once the group was settled, the children were asked about their experiences with pop corn. The teacher initiated questions such as: 'Who has eaten popped corn?' 'How was it cooked?' 'When and where did you eat it?' Responses governed by each child's experience included: 'It cooks in the microwave, in a bag'. 'It stinks'. 'You put butter on to make it taste nice'. 'No, you put salt on it'. 'You eat it when you watch TV'. 'It's white'. 'If you buy it, it's got colours'. 'It's only white'. 'You buy it in a bucket at the movies'.

This prolonged question and answer time provided an opportunity for children to elaborate their past experiences. Each child was given a piece of corn in its seed state to observe. They were then asked to use their five senses to investigate the seed and talk about it with the person sitting next to them. Following this short discussion, the children were told to keep this corn seed because they would need it later for scientific purposes. Selected children then reported their findings to the group regarding the look, smell, sound, feel and taste of the seed. The teacher prompted and insisted on 'full sentence answers'. She also modelled possible responses and congratulated participation.

When the oil in the electric fry-pan was fully heated, seeds were placed into the pan and the heated corn started popping all over the place. Shrieks of joy and laughter filled the room. Exclamations included: 'It's flying!' 'It's shooting!' 'It's going up high'. 'Look! It's on the shelf'. 'Look! It's landed on me'. 'It's snowing everywhere'. Continuous excited chatter and wide-eyed amazement from the children, as the corn popped around the room, made this activity a joy to observe.

The children were then asked to collect one wayward piece of popped corn each and reminded not to eat any. Next, they used their five senses to test the cooked product and talk about their findings with the person sitting next to them. While this conversation happened, the teacher and EA safely removed the pan and oil splattered paper from the floor. As the lesson continued with the teacher, the EA cooked more corn in the kitchen and placed small paper bags of popped corn into each child's locker to take home.

The teacher resettled the children in their semi-circle before asking them for a comparison between the two pieces (uncooked and cooked corn). Comparisons included hard to soft, no smell to good smell, hard to squishy, brown to white and small to big. As before, responses had to be elaborated and questions from the teacher prompted more expansive language. For example, if a child stated, 'It smells different', the teacher would ask, 'What did it smell like before it popped and how is it different now?' Other comparisons from the children included 'The corn was hard before it was cooked and now it is soft' and 'The corn changed from brown to white'.

After the activity, the children were free to play independently in a learning centre of their choice. There was no further follow-up with the popping experience until just before ‘home time’. Once the children were packed up and seated in a ‘sharing circle’, they were asked to recall what they had done that day. The only details about popping corn that the children remembered were the smell, the pieces that ‘flew up high’, and they had some popcorn to take home. The experience and scientific concept of ‘change’ had been largely forgotten.

18.3.3.3 Interpretation

This activity began with such promise yet provided a learning opportunity lost. The children thoroughly enjoyed watching change take place as the corn popped. They enjoyed examining the uncooked and cooked state of the corn, however grew listless when they were not more practically engaged. Sitting in a large group longer than their concentration span and interest allowed did not assist the concept development. Most children were able to report change when questioned during the activity, yet had difficulty recalling scientific details of the experience during the sharing circle time.

Treated as a one-off science activity, little scientific learning occurred as a consequence of not following up the corn activity. Many strategies could have been used to capitalise on the initial excitement and wonder of the children. For example, with assistance from the EA, small groups of children could have cooked their own take-home serve of popcorn. This more intimate experience with the EA could allow the children to talk through their experience, providing an opportunity to ask more questions and consolidate the learning. A free-play learning centre featuring corn could have been established where children could expand their experience with corn. This centre could include a container of corn seeds to play with, plunge hands into, measure, spoon, pour or count. Implements to inspire play, such as containers, a balance and a ladle, would add more learning opportunities. Role playing a piece of corn popping would have personified the change sequence they witnessed. Additionally, photographs could have been taken of the corn popping and, along with comments made by the children, made into a story book. This book would then be used to explain and elaborate the scientific concept of change. Not only was the opportunity to extend scientific understanding of the demonstration lost when the children were not encouraged to discuss related thoughts with an adult, but they were denied a chance to move into a ZPD to actualise potential. These extra strategies would have enabled children to consolidate present knowledge and gain new knowledge while offering rich opportunities for the teacher’s reflections and future planning.

18.4 Conclusion

Each of the three case studies presented offers a different aspect of scientific inquiry by young children, and various pedagogies engaged to deliver those experiences. The richness and appropriateness of staff interactions with children through guiding, modelling and questioning, plus the acceptance of young children's competence and potential are the basis of quality pedagogy (Elliott 2006; Johansson and Emilson 2010). Examples illustrate competence through enabling individual pursuit and interaction in guided play to develop potential, and while the corn-popping experience largely missed the intended scientific concept of change, important questioning skills were developed. Where the pedagogies and experiences related to each scientific inquiry had merit, opportunities for science teaching and learning were lost. For example, a rich opportunity to engage the theory of a ZPD was lost when the corn-popping experience was not extended, whereas children classifying the seed pods were guided to a higher level of engagement and learning by an adult who acknowledged their potential development. Skater Boy, on the other hand, led his own learning to new levels through purposeful play and competence.

Opportunities for educators to gain insight into a child's potential are presented during purposeful play, through responses to open-ended questioning and through discussions during guided play. Actively observing and listening to children as they divulge their interests and knowledge provides a layer of rich information and planning material for the educator (Fleer 2006). This knowledge then directs the establishment of appropriate support, resources and learning centres that offer children science investigations designed to extend their potential cognitive and physical development.

Children are innate explorers and researchers, yet facilitation is required to encourage scientific characteristics and develop sound skills. Johnston (2009, p. 2512) states that the development of good observational skills, for example, needs to be supported by focused teaching. Children are naturally curious. They love to be involved in playful inquiry and have an innate interest in the world in which they live. As such, children are constantly trying to make sense of their everyday experiences and to satisfy their curiosity. The thrill of experiencing popping corn, building a skateboard and being able to create an imaginary train line from leaves are examples of children having a desire to be involved in unravelling the workings of their world and of adults assisting learning. Given the everyday nature of science and the potential of a child, an obvious starting point for planning an integrated curriculum would be based on scientific concepts.

When questioned, teachers' responses about the importance of science teaching and learning varied and did not appear to match the investigations in two ELCs. Where the experience in ELC2 enabled the children to advance their scientific knowledge through hands-on engagement, the experience in ELC1 tended to lose its initial possibilities as children lost interest and no follow-up activities to embed the learning, provided. In contrast, a liberal approach to learning in ELC3 gave children an unstructured environment where they could freely use resources to advance skills according to their own agenda, all the while being encouraged and supported by caregivers.

Having interested adults as active participants in the child's learning environment is essential (Johnston 2009). This role includes actively listening to children's ideas, providing guidance rather than answers, initiating and stimulating talk and modelling how to think things through in a logical sequence. Exciting socio-cultural settings with unimpeded spaces in which a child can wonder about things, chat to others and investigate everyday curiosities can engage their ZPD and thus increase understanding of scientific concepts. This research has found that a balance of planning, flexibility, deliberate teaching and free play is required for a sound platform on which harmonious and positive science learning can occur for young children. Intelligent, thoughtful pedagogy that creates a positive attitude towards science will incorporate meaningful investigations that meet both policy demands and a child's interest whereas over regulated demands and practical constraints will impede learning for young children.

The greatest challenge for early childhood educators is to convince others that play is an integral part of a child's life, even after school has started. Rigorous efforts must be made within the education community to reinforce the value of guided play and intentional, reflective planning for the sound development of scientific skills and concept development in ELCs.

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References

Elliott, A. (2006). *Early childhood education: Pathways to quality and equity for all children*. Camberwell: Australian Council for Education Research.

Fleer, M. (2006). "Meaning-making science": Exploring the sociocultural dimensions of early childhood teacher education. In K. Appleton (Ed.), *Elementary science teacher education: International perspectives on contemporary issues and practice* (pp. 107–124). Mahwah: Lawrence Erlbaum Associates.

Fleer, M. (Ed.). (2007). *Children's thinking in science – What does the research tell us?* Watson: Early Childhood Australia.

Fleer, M., & Robbins, J. (2003). "Hit and run research" with "hit and miss" results in early childhood science education. *Research in Science Education, 33*(4), 405–431.

Johansson, E., & Emilson, A. (2010). Toddlers' life in Swedish preschool. *International Journal of Early Education, 42*(2), 165–179.

Johnston, J. S. (2009). What does the skill of observation look like in young children? *International Journal of Science Education, 31*(18), 2511–2525.

Millikin, J. (2003). *Reflections: Reggio Emilia principles within Australian contexts*. Castle Hill: Pademelon Press.

Mulaguzzi, L. (1998). History, ideas and basic philosophy: An interview with Lella Gandidni. In C. Edwards, L. Gandidni, & G. Forman (Eds.), *The hundred languages of children: Advanced reflections*. London: Alex.

O'Sullivan-Smyser, S. (1996). *Professional's guide: Early childhood education*. Sydney: Hawker Brownlow Education.

Rinaldi, C. (2005). *In dialogue with Reggio Emilia: Listening, researching and learning*. London: Routledge Falmer.

Robbins, J. (2005). Brown paper packages: A socio-cultural perspective on young children's ideas in science. *Research in Science Education, 53*(2), 151–172.

Robbins, J. (2008, July). *The mediation of children's thinking about natural phenomena through conversations and drawings.* Paper presented at the thirty-ninth annual conference of the Australasian Science Education Research Association, Brisbane, Queensland.

Rogoff, B. (2003). *The cultural nature of human development*. Oxford, NY: Oxford University Press.

Szarkowicz, D. (2006). *Observations and reflections in childhood*. South Melbourne: Thomson Social Science Press.

Venville, G., Adey, P., Larkin, S., Robertson, A., & Fulham, H. (2003). Fostering thinking through science in the early years of schooling. *International Journal of Science Education, 25*(11), 1313–1331.

Wildy, H. (1999). Statues, lenses and crystals: Looking at qualitative research. *Education Research and Perspectives, 26*(2), 61–72.

Yin, R. K. (2003). *Case study research: Design and method* (3rd ed.). Thousand Oaks: Sage Publications.