

# Planting the Seeds of Science. Development and evaluation of a new flexible and adaptable early childhood science resource

By Christine Howitt

**Planting the Seeds of Science is a new early childhood science resource developed through a collaboration between science/engineering academics, early childhood teacher educators and early childhood pre-service teachers, with funding from the Australian Learning and Teaching Council. Based on best practice early childhood principles, the resource was designed to allow teachers maximum agency through interpretation of information, flexibility in choice of learning experiences, and adaptability in modifying learning experiences. This approach to curriculum development acknowledges teachers as professionals, and that the teacher best knows their children and interests, the teaching context, the environment, and the outcomes they wish to achieve. This paper outlines the emergent development of the resource, and presents an evaluation through multiple case studies.**

## INTRODUCTION

In his comprehensive review of the crisis in science education, Russell Tytler (2007) proposed re-imagining science curriculum. Within his re-imagined vision, Tytler emphasised recognising teachers as professionals, and allowing them flexibility and creativity in what and how they deliver curriculum. He recognised, however, that such changes need to be supported with appropriate resources that themselves are flexible and embedded in contexts that are meaningful for students. Likewise, in their Australian School Science Education National Action Plan 2008-2012, Goodrum and Rennie (2007, p. 13) highlighted the need for quality teaching resources which allowed 'diversity and flexibility in teaching'.

In describing early childhood curriculum, McLachlan, Fler and Edwards (2010) considered such curriculum should be constructed, contested and emergent: constructed by the children, the parents and members of the community; contested in that all these groups have a say in what the curriculum can and should be; and emergent in that it derives from children's interests. These authors also highlighted the dynamic process of implementing a curriculum, as teachers interpreted how the curriculum could be used within their classroom (McLachlan, Fler & Edwards, 2010).

As a means of increasing student engagement in learning, flexible and adaptive science resources are being encouraged. But what do such resources look like? How are they developed? And how effectively can they be used in the classroom? This paper reports on the development and evaluation of a new early childhood science resource, *Planting the Seeds of Science*, that was based on a flexible and adaptive approach. The first part of the paper presents the background for the project, and positions the research within early childhood teacher education. The process used in developing the resource is described, including a description of the philosophy and template. Each of the five developed science modules within the resource is described. An evaluation of the resource is

presented as five short case studies, with a cross case analysis. This information is then interpreted in relation to curriculum initiatives and development.



Figure 1: Planting the Seeds of Science.

## BACKGROUND

Science is a subject that primary and early childhood teachers tend to avoid in the classroom (Harlen & Holroyd, 1997; Watters & Ginns, 2000). Various reasons have been attributed to this including early childhood professionals' limited scientific knowledge and lack of confidence and competence to teach science (Appleton, 2006; Harlen & Holroyd, 1997), their lack of understanding of what science looks like at the early childhood level and where science occurs in everyday situations, and their inability to extend or capitalise on young children's thinking (Fler, 2009b; Fler & March, 2008). The lack of support for the place of science in early childhood education (with the emphasis instead focusing on literacy and numeracy), along with the

lack of resources for supporting science education have also contributed to the limited implementation of science within early childhood education (Eshach & Fried, 2005; Fleer & March, 2008; Peterson & French, 2008). These issues are considered to be even more of a concern for pre-service teachers as they interact during practicum with experienced teachers who question the value and place of science (Fleer, 2009a), and the subsequent lack of suitable role models from which to observe effective science teaching and learning in the early childhood years (Skamp & Mueller, 2001).

As a means of addressing some of these issues, the *Collaborative Science Project* was developed between 2008 and 2010 at Curtin University, Western Australia, with funding from the Australian Learning and Teaching Council. The *Collaborative Science Project* took a cross-discipline approach to better preparing pre-service early childhood teachers to teach science. Collaboration between science/engineering academics, early childhood teacher educators and early childhood pre-service teachers was used to develop the science resource, implement it into an early childhood science methods course, and subsequently evaluate it in the early childhood classroom. The aim of the *Collaborative Science Project* was to increase pre-service teachers' science content knowledge along with their confidence and competence toward teaching science, as well as develop a new early childhood science resource. This paper reports on the development and evaluation of the science resource. For a more detailed description of the collaboration process and the pre-service teachers' increase in confidence and attitudes towards science during this project, refer to Howitt et al. (2009).

## METHODOLOGY

This section of the paper describes action research as participatory curriculum development, the participants in the project, the development of the philosophy behind the resource, the template used to develop the five modules within the resource, and the development of the five modules.

### Action research as participatory curriculum development

Acknowledging that action research is a process of inquiry incorporating multiple stakeholders (Stringer, 2008), a participatory curriculum development approach was utilised throughout the research. Participatory curriculum development encourages diverse stakeholders in participatory procedures to create curricula that incorporate their needs, perspectives and interests into effective programs of learning (Stringer, 2008). Through this approach, the five science modules were developed, trialled, evaluated and redeveloped in an ongoing manner by a range of participants.

### Participants

A wide range of participants were involved in developing and evaluating the resource: the original Project Team, pre-service early childhood teachers, and experienced in-service early childhood teachers. Each group, and their role in the project, is briefly described below.

The Project Team consisted of ten members from two Western Australian universities, five each from teacher education and science/engineering. One member from each discipline was also involved at a strategic leadership level. Each science/engineering academic

was individually invited to be part of the project, based on recognition of their exemplary undergraduate teaching and learning record, ability to work in a group, and their perceived ability to interact in a positive and supportive manner with early childhood pre-service teachers. The relationship between the science/engineering academics and the teacher educators was an example of integrative collaboration (Ritchie, 2007). Integrative collaboration is based on prolonged periods of committed activity, where partners thrive on dialogue, risk taking, and a shared vision, and are motivated by the desire to transform a situation (Ritchie, 2007). The science/engineering academics and teacher educators worked together over a period of time to develop the content of the five modules (see below). Together, one science/engineering academic and one teacher educator would team teach various parts of the modules within the science methods course. Evaluation of the content of the modules was ongoing by all members of the Project Team, through debriefing sessions, focus group interviews, verbal feedback and written questionnaires.

One cohort (2008) of pre-service teachers in the Bachelor of Education (Early Childhood) degree at Curtin University, represented the main participants in the project. This cohort of thirty-eight students, who undertook their third year science methods course in Semester 2, 2008 followed through with this project to their final teaching practice in Semester 2, 2009. These pre-service teachers provided ongoing evaluation of the modules through verbal feedback and written questionnaires. Two of the pre-service teachers, who trialled the modules during their practicum, became case studies for the project. Evaluation of the modules from these two teachers was obtained by observations within classrooms, children's work samples, and audio-recorded interviews.

Early childhood in-service teachers were used in two capacities. The first group of four teachers was classified as consultants and gave ongoing feedback throughout the entire project. These four teachers had a range of early childhood classroom experience from five through to 20+ years. As an integral part of the project, they were kept informed of all processes and invited to participate in as many of these as possible. Feedback from these consultants was obtained through focus group interviews, individual interviews, and formal and informal written feedback. A second group of three practising early childhood teachers agreed to trial and evaluate the modules in their classroom. All were based in the Perth metropolitan area and all taught in independent schools. These trials subsequently became case studies for the project. Evaluation of the modules from these three teachers was obtained by observations within classrooms, children's work samples, and audio-recorded interviews.

Interviews with the five early childhood teachers who evaluated the modules in the classroom were based on the following questions: What is your experience and enthusiasm for teaching science?, How was the resource used?, Which parts of the resource were most useful and why?, Which modules appealed to you and why?, and What do you consider to be the advantages and limitations of the resource?

### Development of philosophy

Each module was developed around a philosophy that embedded five main principles based on best practice in early childhood education. These five principles are summarised in Table 1.

PRINCIPLE	DESCRIPTION
1. Acknowledgement of the place of young children as natural scientists	Children demonstrate an immense curiosity and thirst for knowledge as they question everything around them, engage their five senses, and try to make sense of their world.
2. Active involvement of children in their own learning through play and guided inquiry	Play affords many opportunities for children to learn through discovery, creation and imagination. Guided inquiry acknowledges the active involvement of children in their own learning through structured experiences provided by the teacher.
3. Recognition of the place of a socio-cultural context for children's learning	Children do not learn in isolation, but rather through the many interactions they have with others. Children's personal, social and cultural context all contribute to their learning.
4. Emphasis on an integrated approach to children's learning experiences	An integrated approach provides children with opportunities to develop relationships and links between learning. This approach embraces teachable moments through children's everyday questions, investigations and social encounters.
5. The use of a variety of meaning making practices for children to demonstrate their understanding and learning	Children use many 'languages', or representations, to make meaning of their world. These include talking, reading, writing, singing, drawing, constructing, painting, storytelling, imagining and acting. These different representations allow children to revisit their own learning at a pace and in a context that suits them, and to present their understanding according to their skills and ability.

Table 1: Description of the five principles that form the philosophy of Planting the Seeds of Science (adapted from Howitt & Blake, 2010)

## Development of template

The approach to the resource design and development was innovative in that it aimed to produce a flexible, adaptive and integrated curriculum, rather than a teaching program or a syllabus. Thus, the information presented within each module was developed to provide a range of possible science ideas and activities that could be used in the early childhood classroom. This approach to curriculum acknowledged that teachers are professionals, and that the teacher best knows their children and their interests, the teaching context, and the outcomes they wish to achieve.

The template for each module was based on the following information:

- an overview
- an introduction with a range of ideas and activities
- focus questions relating to the introduction
- a range of follow-up sub-themes, each with their own ideas and activities
- a conclusion with a range of ideas and activities
- a list of resources that include people, websites, narrative and factual books, and raps and rhymes
- suggestions for diagnostic, formative and summative assessment

- background information in the form of questions and scientific answers that can easily be explained to children
- suggestions for curriculum integration
- suggestions for addressing the five Learning Outcomes of the *Early Years Learning Framework*
- suggestions for addressing the three strands of the *Australian Curriculum: Science*, and
- a case study illustrating how the module has been implemented in the early childhood classroom.

While each module contained an Introduction and Conclusion, a wide range of varying learning experiences could be implemented in the classroom between these two end points. This allowed the teacher flexibility in choice of learning experiences, and adaptability in modifying learning experiences to suit a given class, context or environment. The aim of including information on resources, ideas for assessment, science content knowledge in the form of Q&A, and integration across the curriculum was to provide a document that could readily be used for planning, teaching and assessment. To make it as relevant and up-to-date as possible, the resource also addressed the nationally mandated *Early Years Learning Framework* (Commonwealth of Australia, 2009) and Version 1.0 of the *Australian Curriculum: Science* (Australian Curriculum, Assessment and Reporting Authority, 2010). Each module finished with a case study, highlighting how teachers had used the information within a classroom context.

## Development of modules

The role of the science/engineering academic working with the teacher educators in developing the modules was emergent and highly collaborative. The science/engineering academic was considered the 'content' expert, while the teacher educators were the 'early childhood' and 'pedagogy' experts. Starting with a brainstorming session, there was continuous feedback between the science/engineering academic and the teacher educators as each module developed. This process took between three to six months, as a sequence of possible ideas and activities were discussed, developed, discarded or refined.

## RESULTS

The results are presented in two sections. The first section provides a description of the five developed modules. The second section presents the evaluation of the resource through five case studies and a cross-case analysis.

## Summary of modules

Five modules were developed around the general themes of the environment, day and night, forensic science, cleanliness and solar energy. A summary of the five modules, adapted from Howitt and Blake (2010), is presented below.

### Module 1: Look what we found in the park!

Children love exploring their outside environment. *Look what we found in the park!* allows children to develop a greater sense of their local environment and their place within it. The module starts with children exploring a local park, bush area or beach, the school yard or the school's suburb and collecting a range of objects that provoke interest. These objects then become the

basis of activities for children to increase knowledge of their natural environment, connections with it, and an awareness of their responsibility towards that environment.

*Look what we found in the park!* provides children with the opportunity to discover and explore in detail, trees and their many components (leaves, barks, nuts, seeds, sticks and flowers), produce park art, celebrate the many shades of green or brown found in nature, map the park, adopt an animal as a mascot, turn their classroom into a park, and revisit their park in a different season.

### Module 2: Is the grass still green at night? Astrophysics of the dark

The rhythm of day and night is a part of everyone's life and children can easily relate their experiences of day light and night time dark. *Is the grass still green at night?* Astrophysics of the dark introduces children to scientific concepts related to day and night. This module is designed to expand a child's knowledge of why there is a light and a dark part of every day through developing a greater understanding of the characteristics of day and night, exploring shadows, and observing the relationship between Earth and the Sun.

*Is the grass still green at night?* Astrophysics of the dark begins with children discussing living and working during day time, and living and working at night time. The night time discussion acknowledges that some children are afraid of the dark and sensitively addresses this issue. It also discusses monsters, and allows children to confidently experience being in the dark. A comparison between day and night is then made. Children investigate how shadows are made, by examining shadows of themselves, the changing shapes of shadows, and shadows on balls. Using the relationship between the Sun and the Earth, children explore day and night with various hand-held models. Finally, they answer the question, 'Is the grass still green at night?'

### Module 3: We're going on a (forensic) bear hunt!

Children love being part of a mystery. *We're going on a (forensic) bear hunt!* introduces children to the fundamental principles of forensic science, and allows them to solve a class mystery. The children are initially presented with a set of bear footprints. However, any footprints appropriate for the context could be used. For example, unique Australian animals such as the emu, kangaroo or lizard, or farm animals such as the horse, pig or duck. Through the completion of various basic forensic activities where children collect clues and evidence using their observational, descriptive and classification skills, they solve the mystery. The song and actions to Michael Rosen's story *We're going on a bear hunt* are used to elaborate the experiences.

*We're going on a (Forensic) bear hunt!* provides children with the opportunity to solve a class problem while at the same time becoming more familiar with their body. Children compare their footprint, handprint and hair with those that the bear has left behind, as they learn about their own uniqueness. Children observe the detail of cuts to patterned paper as they determine what instrument cut the paper. They also investigate which type of food can be used to make obvious fingerprints. Finally, they bring all the evidence together to determine who left the footprints in the classroom.

### Module 4: Muds and suds: The science of cleanliness

Cleanliness and hygiene are concepts that children can readily relate to by the time they start school. *Muds and suds: The science of cleanliness* is designed to

expand children's basic knowledge of these concepts in relation to themselves and their everyday life. This module aims to promote in children a greater sense of responsibility in maintaining their own health through an understanding of how and why both animals and humans wash themselves, the differences between dirty and clean, and how soap works.

The module begins with the children being introduced to the Joy Crowley book, *Mrs Wishy-washy*, to discuss why and how the animals in the story were cleaned. Children then investigate various ways that animals stay clean, make a comparison of how they get dirty and how they get clean, explore the properties of mud, and find out how soap works. Opportunities to investigate bubbles and discover how wet objects dry out are also provided.

### Module 5: The Sun changes everything!

Children can easily relate to their experiences of warmth from the Sun and other heat sources. *The Sun changes everything!* has been designed around everyday experiences to expand children's knowledge about how the Sun's heat and light energy influence their lives. Energy is a very abstract concept for young children to comprehend. It is therefore best to focus on how energy is associated with situations undergoing change that they can easily relate to, rather than trying to define energy. Hence, the emphasis within this module is on the influence of the Sun's energy on a child's everyday life and how the Sun's energy can change things.

The module begins with a puppet, symbolising an Australian reptile in search of a suitable place to warm up. A frilled neck lizard called Freda is used to introduce reptiles and their need of the Sun's light energy. The characteristics of a lizard are then compared with those of a human. This is followed by a sequence of activities to investigate the power of the Sun by identifying warm and cool places inside and outside of the classroom, and how a range of familiar objects can change if left in sunlight. The module concludes with the production of a basic solar cooker to make 'sun-bread'. Freda features throughout the module with reference to her need of the Sun's heat to live.



Figure 2: Introducing children to forensic science through footprints found in the classroom.

## Evaluation of 'Planting the seeds of science'

A major component of the evaluation of the resource was five teachers each trialling a different module in their classroom. Two were pre-service teachers on practicum, while the remaining three were experienced in-service teachers. The five case studies are presented below, summarising how the module was used, how it was modified, and what the teacher thought of the resource. This is followed by a cross-case analysis of perceived strengths of the resource.

### Case Study 1

Sandra (a pseudonym), an experienced teacher in a large independent K-12 school in Perth, trialled *Look what we found in the park!* with her Year 1 class of twenty-seven children. Sandra selected various activities from this module to develop a six week teaching program for Term 4 that would cover all learning areas. Her aim was to develop rich integrated learning experiences for the children that would help them to connect more with their local environment.

As pine trees were a feature of the local environment, Sandra found these to be a catalyst to integrate Science, Society and Environment, Art and Literacy. In class, the children discussed the differences between pine trees and eucalyptus trees, the uses of pine wood, where pine trees originated, and why the pine trees were located next to the school (relating this to underground water). The children were also introduced to charcoal, discussed how it is formed, how it is used in art, and had the opportunity to sit outside, view the pine trees and draw them with charcoal.



Figure 3: Connecting children with their local environment through drawing pine trees using charcoal.

Sandra found the resource presented rich integrated learning experiences across all the learning areas. In particular, she was impressed with how the themes were explored through the different learning areas, starting with what the children already knew. She believed the structure of the module gave the teacher the flexibility to explore topics creatively and lead the children on their own learning journey.

Sandra found this book demystified science and the preciseness of the topic, and removed the anxiety attached to teaching science. She found the book both easy to use and easy to plan around, because it provided starting points and a wide range of activities. Sandra loved the choice of activities and ideas; however, she also recognised that others may not like such flexibility.

Sandra recognised that the structure of the book allowed, and even encouraged, the teacher to go off on a tangent based on children's ideas and questions. Sandra commented that the book modelled how to develop an integrated program from any theme. She also highlighted that the structure of the modules allowed reflection and growth within teaching and learning science in early childhood education.

### Case Study 2

Jill (a pseudonym), an experienced early childhood teacher in a large Perth independent school, trialled *Is the grass still green at night? Astrophysics of the dark* with her pre-primary class of twenty-six 5-year-old girls. Jill selected various ideas and activities from the module which she considered appropriate for her class. She started the module with a group discussion to find the girls' notions about whether or not the grass was green at night. Children's ideas ranged from the grass being blue, dark green, brown, silver and green at night. The children then made their own comparisons between day time activities and night time activities.

Without a consensus about whether or not the grass was in fact still green at night, and without the opportunity to have a sleep over or a late night at the school for the girls to test their ideas, the class discussed ways to remedy this conundrum. The solution to this became placing a box, with a hole in it, over some grass in a dark place at school, and using a torch to represent the light which bounces off the Moon.

Jill found the book very easy to use, and that it presented ideas that could be readily planned. She was pleased that it acknowledged that even the youngest students have knowledge to build on. Jill also liked the variety of ideas and activities to choose from. She acknowledged that the flexibility this offered was best for her class because, "I know my students and what their interests are so I can adapt these ideas to suit their science needs."

Jill went on to explain how this particular resource did not expect a teacher to be rigid about what had to be taught for science in early childhood education. This enabled the teacher to move to where the children's interests were, and because of its early childhood appropriateness, avoided the tendency to 'push down the curriculum'.

### Case Study 3

Elizabeth (a pseudonym) was a third year pre-service teacher who completed her three week practicum with a class of twenty kindergarten (4-year-old) children in a Perth government primary school. She trialled the module *We're going on a (forensic) bear hunt!*

Elizabeth was restricted to delivering six half-day science lessons with the children. She decided to follow the same sequential order as presented in the module, but only chose one or two of the activities from each sub-theme that were appropriate for Kindergarten. She found it very easy to modify the activities for the age group, time frame and availability of resources. Her choice of activities included discovering bear footprints, discovering fur, discovering honey paw prints, planning and conducting a class investigation on 'What foods can we make fingerprints with?', going on a bear hunt outside, and having a whole class teddy bears' picnic.

Elizabeth found *Planting the Seeds of Science* to be an extremely useful guide as she planned and delivered her lessons. She felt that all information required was at her fingertips: activities, focus questions, websites,

questions and answers, integration, and even songs. Elizabeth commented that the book was very easy to use, noting that she could always see the bigger picture of the overall lessons, even when delivering an individual lesson. The flexibility to take the ideas and activities and make them appropriate for her context was considered to be a huge advantage of the book.

Elizabeth conveyed stories of engaged, motivated and immensely excited children during the forensic science activities, which made teaching science easy. Elizabeth believed the success of the program was evident by the responses from the children, which reflected their interest in the topic.

#### Case Study 4

Lily (a pseudonym) was a fourth year pre-service teacher who completed her eight week final teaching practicum with a class of twenty-four Year 1 children in a Perth independent school. Lily trialled the module *Muds and Suds: The science of cleanliness*.

Lily was asked by her supervising teacher to teach the theme 'Looking after your body' for Health. To assist her programming, she consulted the *Muds and Suds* module. Lily found *Planting the Seeds of Science* provided her with wonderful ideas to assist in the development of her health and science program. The flexibility to pick and chose activities from any modules that were most appropriate for her class was considered a real strength of the book. Lily continually referred to the activities, resources, assessment, Q&A, and integration components of *Muds and Suds: The science of cleanliness* as she found they contained the "essential information needed when planning and documenting learning."

Lily particularly liked to use the integration of the different learning areas within the modules. Even though she was required to teach health, she had access to a science book which gave her not only excellent health activities and ideas, but provided answers to many of the questions the children asked. The integrated approach of the book allowed Lily to effectively link science across all the learning areas, and teach a new topic with confidence and success.

#### Case Study 5

Hannah (a pseudonym) was a Pre-Primary teacher of twenty-seven children in a large K-12 independent school in Perth. She has been teaching for four years. Hannah had originally planned to study *Space for the term*. Upon reading *Is the grass still green at night? Astrophysics of the dark* and *The Sun changes everything!*, however, she could see clear links between these two modules. Thus, she decided to use the Sun as the basis of her program, shifted the emphasis from 'day and night' to 'light and dark', and utilised ideas and activities from both modules.

In planning her program, Hannah decided to start with the science concepts presented in the modules and from there integrate across the different learning areas. Hannah believed that the modules as a whole assisted programming in many ways and provided the majority of the information needed to meet her and the school's programming requirements. She was very impressed with the wide range of practical ideas and activities presented in the modules, and could see that these would assist many teachers with their science programming. The activities in the modules were very

easy to organise with her Education Assistant, and to conduct with the children. Hannah also found the progression through the activities an excellent way to build children's understanding of the topic.

As already mentioned, Hannah embraced the suggestions for integration across the learning areas. She felt these integration ideas allowed early childhood teachers to teach in the holistic manner in which they had been trained. Hannah was also very impressed with the depth of science content knowledge that was presented within each module. She believed the modules allowed teachers to not only learn a scientific concept, but also provided suggestions on how to teach that concept in an early childhood context.

#### Cross case analysis

All five teachers used the modules in a different way and modified activities to suit their class and context. The perceived strengths of the modules, as expressed by the case study teachers, are presented in Table 2 for each case study.

CASE STUDY	PERCEIVED STRENGTHS OF THE MODULES
1	Rich integrated learning experiences, structure of modules, flexibility to explore topics creatively, removed anxiety attached to science, easy to use and easy to plan, large choice of activities and ideas
2	Easy to use, variety of activities and ideas, flexibility that acknowledges the teacher knows the class best, allowed teacher to follow children's interests, Q&A assisted with correct scientific facts, assessment ideas made tasks easier
3	Extremely useful guide to planning and delivering science, easy to use, flexibility to take activities and ideas and make them appropriate for the context, integration across the areas of the curriculum, age appropriate themes and context
4	Range of activities and ideas, flexibility to pick and choose activities that were appropriate to the class, contained essential information required for planning and documenting learning, integration across the areas of the curriculum.
5	Assisted programming in many ways, wide range of practical ideas and activities, activities easy to organise and to conduct with the children, integration across the areas of the curriculum, allowed you to teach in a holistic manner, depth of science content knowledge presented, practical and child-friendly

Table 2: Strengths of the modules based on the five case studies.

Common strengths of the modules from the five case studies were the:

- range of ideas and activities presented
- flexibility to adapt for a given context
- integration across the areas of the curriculum
- ease of use in planning and programming

These commonalities reinforce that *Planting the Seeds of Science* was being used in the manner intended: as a flexible and integrated science resource that could be readily adapted for a given class and context. *Planting the Seeds of Science* was found to be useful for both pre-service and practising early childhood teachers, and considered by all who tested the modules to be a valuable science resource in early childhood education.

Minimal limitations of the resource were identified by the five case study teachers. One limitation noted was that for teachers who prefer a prescriptive document for teaching science, the flexible nature of the resource may actually act as a deterrent to its use. Another limitation was considered to be the lack of information on ideas for setting up the classroom to follow the theme of each module. However, in keeping with the flexible approach of the resource, photographs of classrooms where teachers had trialled the modules were presented to provide a range of possible ideas for establishing an engaging classroom environment. All case study teachers commented on their desire to see more early childhood science resources developed using this flexible and adaptive approach.

## DISCUSSION

*Planting the Seeds of Science* is a resource that maximises teacher agency by allowing teachers to interpret the modules and make decisions about what is appropriate for their class, context and environment. Such agency has been achieved through the use of a template that presented many ideas and activities under different sub-themes. Detailed descriptions of ideas and activities were not used, to avoid a prescriptive model of curriculum design. Instead, the ideas and activities serve as 'hooks' for teachers to attach. Due to the highly integrated nature of the resource, that hook could represent any one of the curriculum learning areas. Such an approach acknowledges that early childhood teachers have strengths in many areas (Howes, 2002), and allows them to work with these strengths while connecting with science in a manner that is comfortable for them. This innovative approach to curriculum design, as found in the five case studies, encouraged teacher flexibility, improvisation, adaptability and creativity in developing and implementing a classroom curriculum.

The flexible and adaptive nature of the resource was readily illustrated throughout the case studies. All five case study teachers adapted the modules in a different manner to suit their class and context. For example, in Case Study 1, an integrated approach was used to take advantage of the local environment. In contrast, Case Study 5 illustrated how two modules could be used to develop appropriate learning experiences and a sequential teaching program. Unlike some curriculum documents that present prescriptive teaching programs, or present an activity that can only be done in one way, *Planting the Seeds of Science* allows and encourages teachers to modify and adapt. This approach to curriculum development embraces the holistic nature of teaching and learning fundamental to the early childhood years.

Within early childhood education, Burgess, Robertson and Patterson (2010) found that the initial decisions teachers make about a curriculum initiative may act as a personal gatekeeper to engagement or rejection of that initiative. All five case study teachers were immediately engaged with the resource. One of the main reasons for this was that the resources had been developed specifically for the early childhood years. These teachers felt that *Planting the Seeds of Science* filled a huge curriculum gap, highlighting the lack of science resources within this age range.

While two of the case study teachers had prior experience with some of the activities through their science methods course, the other three case study teachers did not. These three teachers were informed of the project, given an overview of the philosophy and template used to construct the resource, and

draft versions of the modules. Even without formal professional development on the resource, the teachers expressed enthusiastic and positive attitudes towards the resource, immediately engaged with it, considered the pragmatics associated with using it in the classroom, and went on to implement and adapt various modules for their class and context. While representing a biased sample, as these three teachers volunteered to be part of the project and were interested in teaching science in the early childhood years, the level of implementation and adaptation was surprisingly high. The initial positive engagement and subsequent adoption of *Planting the Seeds of Science*, highlight a successful curriculum initiative.

The process of participatory curriculum development used to produce *Planting the Seeds of Science* illustrated how an emergent process could be utilised to produce an emergent document. The two year process of producing the resource was characterised by flexible and collaborative discussion, development, replacement and refinement. At the start of the project, there was a goal – a tangible outcome in terms of an early childhood science resource. What that resource looked like, and how that was to be achieved, emerged as the project progressed. Having the freedom to develop a resource in such an emergent manner has been immensely beneficial, and has produced a document that teachers can readily use in their planning, teaching and assessment.

## CONCLUSION

*Planting the Seeds of Science* was developed to provide engaging science ideas and activities that would encourage early childhood teachers to teach science. Based on best practice early childhood principles, the resource was designed to re-imagine the curriculum by allowing teachers maximum agency through interpretation of information, flexibility in choice of learning experiences, and adaptability in modifying learning experiences. This approach to curriculum development, acknowledges teachers as professionals, and that the teacher best knows their children and interests, the teaching context, the environment, and the outcomes they wish to achieve. *Planting the Seeds of Science* is a "practical, child-friendly, classroom-based resource that actively encourages teachers to teach science to young children" (Hannah, Case Study 5).

## AVAILABILITY OF RESOURCE

As a requirement of the funding body to make the resource freely available, *Planting the Seeds of Science* was produced under a Creative Commons Licence. Copies of the book can be downloaded from the following website: <http://www.altc.edu.au/resource-planting-seeds-science-second-edition-2010>

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