Chapter 11
Increasing Accessibility to Science in Early Childhood Teacher Education Through Collaboration Between Teacher Educators and Science/Engineering Academics

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11.1 Introduction

Various reports have identified urgent needs for science education in Australia, in particular, in relation to maintaining and increasing capability to teach science at all levels of schooling (e.g. Australian Academy of Technological Sciences and Engineering 2002; Goodrum et al. 2001; Tytler 2007). The most recent reports at both the national and state levels have recommended the development of comprehensive 'action plans'. For example, the Commonwealth sponsored the initial phase of production of a *National Action Plan for Australian School Science Education 2008–2012* (Goodrum and Rennie 2007). Many of these reports highlight a 'crisis' in science education, in terms of students', teachers' and national needs. Briefly, they provided convincing evidence that students are not enrolling in science courses or science education courses in sufficient numbers; appropriately trained teachers of

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science are in short supply; the science-related background of teachers, particularly those at primary and early childhood levels, is inadequate especially in an increasingly scientific and technological society; and the critical shortage of people with science, technology, engineering and mathematics (STEM) knowledge, skills and/or appreciation continues to be a national concern, especially in innovation and economic terms.

Over the past decade, a number of initiatives have attempted to address the student-related dimensions of this problem, particularly increasing engagement in STEM at the upper primary and secondary school levels. Examples of these include the Australian Academy of Science 'Primary Connections' programme, the Collaborative Australian Secondary Science Programme (CASSP), the Creativity in Science and Technology (CREST) programme, the Science Education Assessment Resources (SEAR) programme, the Australian Science Teachers' Association Science Awareness Raising Model and the recent Scientists in Schools (SiS) programme. However, few of the initiatives to date have focused specifically on the needs of pre-service teachers, and even fewer have addressed the needs of early childhood pre-service teachers.

This chapter reports on the outcomes of a project that took a highly collaborative and cross-discipline approach among teacher educators, science/engineering academics and early childhood pre-service teachers to encourage the latter to teach more science, with greater confidence, in the classroom. This collaborative approach involved both the development and delivery of science modules within a science methods course. For the purposes of this research, early childhood was defined as children between the ages of 3 and 8 years. The first part of this chapter describes the literature in relation to three relevant areas of research. First, the characteristics of early childhood pre-service teachers are described in relation to science. Second, various approaches used to improve pre-service teachers' confidence and competence to teach science are discussed. Third, an overview of collaboration between scientists and teachers is presented. In the remainder of the chapter, the project design and findings are discussed.

11.1.1 Characteristics of Early Childhood Pre-service Teachers: A Focus on Science

Based upon their diverse backgrounds and individual experiences, pre-service early childhood teachers bring a unique set of characteristics with them when they are learning about science and how to teach science. Pre-service teachers bring many strengths, and thus potential resources, into their teaching and learning. Such strengths include respect for children's intellect, curiosity and questioning; celebration of children's wonder of the natural world; excitement associated with children's exploration and discovery of the natural world; and a willingness to develop instruction based upon children's thinking that embraces

open-ended enquiry (Howes 2002). Fleer (2006) also considered pre-service teachers' informal science knowledge gained through interests and hobbies to be a further strength. Howes (2002) suggested that working with their strengths provides pre-service teachers a greater opportunity to connect with science in a manner that is comfortable to them and subsequently believe in themselves as teachers of science.

In contrast, many pre-service early childhood teachers see themselves as 'non-science' people trying to become science students at university (Mulholland and Wallace 2003). They consider themselves to have poor science knowledge, which tends to be limited in quantity, narrow in perspective and characterized by a lack of understanding of the nature of science (Appleton 2006). Pre-service early childhood teachers often lack previous science experiences or have experienced negative science experiences, mostly in secondary school, resulting in them perceiving science as only for the intellectually gifted or having a masculine image (Mulholland and Wallace 1996). They tend to have poor attitudes and beliefs about science and their capacity to be effective teachers of science (Watters and Ginns 2000), this leading to an avoidance of teaching science (Harlen and Holroyd 1997). Finally, pre-service early childhood teachers tend to have well-developed but often simplistic views of the science teaching and learning process, leading to inappropriate science teaching strategies and learning experiences (Appleton 2006). These factors contribute to the lack of confidence that pre-service early childhood teachers have towards science and the teaching of science.

11.1.2 Improving Pre-service Teachers' Knowledge and Confidence Towards Science

A substantial body of research exists on how best to improve pre-service primary teachers' science knowledge of and confidence towards science. The majority of this research has been directed at improving science content knowledge and science methods courses with the aim of improving the confidence of the pre-service teachers (Appleton 2003). The influence of the science teacher educator in improving the confidence of pre-service primary teachers by creating an effective science learning environment also has been examined to a lesser degree (Rice and Roychoudhury 2003). In general, results indicate that learning environments need to be positive and supportive to minimize anxiety and encourage freedom to experiment and verbalize opinions (Huinker and Madison 1997). Courses should include a variety of authentic teaching methods that concentrate on student-centred learning experiences and make connections with prior knowledge. Pre-service teachers should be supported by consistent feedback to allow for the development of science understanding and pedagogy and improved beliefs and attitudes about science and themselves as teachers of science (Huinker and Madison 1997). These results suggest that the science methods course should include a wide

range of factors to improve pre-service teachers' knowledge and confidence towards science.

Various researchers have advocated a pedagogical content knowledge (PCK) approach in teacher education courses, through successful experiences at the pre-service level, as a means of increasing primary teachers' confidence towards science (Appleton 2003, 2006; Rice and Roychoudhury 2003). PCK is one of many different forms of knowledge that teachers draw upon, which includes subject matter knowledge (or content knowledge) and general pedagogical knowledge (Shulman 1986). PCK is considered different to the latter two forms of knowledge, as it is a form of knowledge in action (Zeidler 2002). Appleton (2006) defined science PCK as 'the knowledge a teacher uses to construct and implement a science learning experience or series of science learning experiences' (p. 35). Science PCK is a dynamic form of knowing as it has close links with a teacher's science content knowledge and is developed through the teacher's own science experiences and science teaching practices (Appleton 2003, 2006).

While science PCK is necessary in order to teach science, it is not automatically generated from science content and other forms of teacher knowledge (Appleton 2006). As a means of developing science PCK, Appleton (2003) suggested pre-service teachers develop a series of activities organized in a pedagogical sequence designed to facilitate pre-service teachers' conceptual understanding. They suggested that such units would include learning experiences, key teaching strategies and explanatory science notes. Appleton (2003) also suggested that science content would be most meaningful to pre-service teachers when it is dealt within a pedagogical context, which includes a focus on student preconceptions and how to deal with these while teaching. These findings suggest that participating in authentic science experiences where both content and pedagogy is made explicit provides an opportunity to increase pre-service teachers' PCK.

11.1.3 Collaboration Between Scientists and Teachers

Improving science education by having scientists work with teachers is not a new idea (Drayton and Falk 2006). The proposition is that scientists working with *K*-12 teachers assist in making that science more meaningful, with the teachers in turn making science more meaningful for their students. Scientists, possessing science content knowledge, process knowledge and the structure of their field of knowledge, are considered an untapped resource of the practical application of science (Drayton and Falk 2006). There are many successful examples of apprenticeship programmes involving scientists in classroom enquiry, fieldwork or laboratory activities (Bell et al. 2003; Crawford 2009; Drayton and Falk 2006; Howitt et al. 2009). Similarly, working at the higher education level, Martin-Dunlop and Hodum (2009) reported on the successful collaboration between a scientist and a science teacher educator to assist pre-service primary teachers' develop their science content knowledge, attitudes towards science and understanding of the nature of science.

11.1.4 Research Questions

The following research questions will be addressed in this chapter.

1. How does a collaborative approach between teacher educators and science/engineering academics to developing and delivering science curricula assist early childhood pre-service teachers' confidence to teach science and science content knowledge?
2. How did the pre-service teachers translate this new knowledge into the early childhood classroom?

11.2 Methodology

The following sections describe the action research approach, project team, development of the science modules, implementation of the modules into the science methods course, evaluation of the pre-service teachers' confidence and science content knowledge and teaching science in the early childhood classroom.

11.2.1 Action Research as Participatory Curriculum Development

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

11.2.2 Project Team

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 scientist/engineer 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.

11.2.3 Development of Modules

Four science modules were developed through collaboration between the teacher educators and the science/engineer academics, covering the themes of day and night, forensic science, the science of cleanliness and solar energy. The information presented within each module aimed to provide a broad range of possible ideas and activities that could be used within an early childhood classroom. The modules were designed to be adaptive and flexible, rather than set teaching programmes, so that teachers could use the materials in a manner that suited their particular context.

A philosophy and template were developed from which to construct the modules (Howitt and Blake 2010). Embracing best practice early childhood education, the philosophy was based upon five principles: acknowledgement of the place of young children as natural scientists, active involvement of children in their own learning through play and guided enquiry, recognition of the place of a sociocultural context within children's learning, emphasis on an integrated approach to children's learning experiences and the use of a variety of methods for children to demonstrate their understanding and learning. Each module was developed around a template that consisted of an overview; a range of introductory core activities that established a suitable context; focus questions relating to these core activities; a range of follow-up activities, including concluding activities; possible resources; suggested forms of diagnostic, formative and summative assessment; questions and answers (covering science content); and suggestions for integration across the different curriculum learning areas.

11.2.4 Implementing the Modules into the Science Methods Course

The developed modules were implemented into a 12-week science methods course during the third year of a 4-year Bachelor of Education (Early Childhood Education) degree during semester 2, 2008. There were 38 pre-service early childhood teachers within this course. The weekly 3-h workshops delivered during the course aimed to develop the pre-service teachers' science PCK through active scientific enquiry. The first author was the principle lecturer for the workshops. Each workshop consisted of a mini-lecture (30–40 min) that presented the science curriculum and each science conceptual area. This was followed by a range of hands-on activities that were specific to one science conceptual area. A sequential range of science activities were either presented in each workshop or provided in a detailed handout relating to that workshop. The science learning experiences within the workshops were characterized by active participation, placement with an authentic early childhood context, discussion of children's views of science and learning within a social constructivist environment.

Each scientist/engineer took an active role in the workshop where the module they had assisted in developing was delivered. A team teaching approach was

modelled between the principle lecturer and scientist/engineer. Through discussion between the principle lecturer and the scientist/engineer, selected activities from the developed modules were chosen to be presented in the workshops.

11.2.5 Evaluating Pre-service Teachers' Confidence and Science Content Knowledge

Data were collected from a range of methods: formal questionnaires, open-ended questions, posters and interviews.

As a general measure of the pre-service teachers' science teaching ability, they were asked four questions in week 2 and again in week 12 of the science methods course. The four questions related to their perceived interest in teaching science, background knowledge for teaching science, confidence in teaching science and enthusiasm for teaching science. These questions had a five-point range of responses from 'Not Interested'/'Limited'/'Not Very Confident'/'Rarely' to 'Interested'/'Extensive'/'Confident'/'Always'. The responses were analysed by descriptive statistics, summarizing pre- and post-percentage responses and presenting these as a comparison.

Pre-service teachers' confidence to teach science was measured with a modified Personal Science Teaching Efficacy (PSTE) scale from the Science Teaching Efficacy Belief Instrument (STEBI-B). PSTE is defined as the belief in one's ability to teach science effectively (Huinker and Madison 1997). STEBI-B has been found to be a valid and reliable instrument for measuring science teaching efficacy in pre-service teachers (Enochs and Riggs 1990; Ginns et al. 1995) and has been used in a wide range of studies (Cantrell et al. 2003; Palmer 2006; Watters and Ginns 2000).

PSTE pre- and post-tests were administered in weeks 2 and 12, respectively. The PSTE was modified by changing all 13 questions to the affirmative, simplifying the questions and allowing a five-point range of responses other than the standard responses of 'Strongly Disagree', 'Disagree', 'Neutral', 'Agree' and 'Strongly Agree'. Depending on the question, responses to the modified PSTE ranged from 'Rarely'/'Limited'/'Different' to 'Always'/'Extensive'/'Easy'. For example, the question 'even when I try hard, I will not teach science as well as I will most subjects' was changed to 'compared with other subjects I will find it easy to teach science' with responses ranging from 'Rarely' to 'Always'. Statistical differences between the pre- and post-test PSTE were obtained with the use of a paired *t*-test.

At the end of the semester the pre-service, teachers were also given an open-ended questionnaire relating to confidence in science teaching and science knowledge. If they thought their confidence to teach science, or knowledge and understanding of science, had changed as a consequence of the science methods course, the pre-service teachers were asked to briefly explain how and why these had changed. Responses to these two questions were analysed, and common themes identified. The percentage of pre-service teachers who commented on each common

theme was then calculated. Comments from the pre-service teachers relating to each theme were used to highlight certain responses.

To further measure the pre-service teachers' learning over the semester, as part of formal assessment, they were asked to produce a poster that summarized what content they had learned in each of the four workshops where a science/engineering academic had been present. Responses on the poster were analysed, and common themes identified. The percentage of pre-service teachers who commented on each theme was then calculated. Comments from the pre-service teachers relating to each theme were used to highlight certain responses.

11.2.6 Teaching Science in the Early Childhood Classroom

At the end of the 12-week science methods course, the pre-service teachers participated in a three-week teaching practice with either 4-year-old or 5-year-old children. The pre-service teachers were encouraged to use the modules to assist them to teach science during this time. However, this could not be mandated as the pre-service teachers were required to follow their cooperating teacher's advice. At the end of the teaching practice, the pre-service teachers were asked to complete a simple open-ended questionnaire on what science they taught in the classroom and how they applied their learning from the modules and the science methods course within the classroom. This was supported with interviews of three purposively selected pre-service teachers to provide more detail on how they had incorporated the modules within their planning and teaching.

11.3 Findings

The findings have been organized around the pre-service teachers' perceived science teaching ability, confidence to teach science, science content knowledge and teaching science in the early childhood classroom.

11.3.1 Pre-service Teachers' Perceived Science Teaching Ability

Table 11.1 presents the percentage response to the four questions relating to the pre-service teachers' perceived science teaching ability. For the pre-test, the pre-service teachers tended to rank themselves average/above average for their interest in teaching science and enthusiasm for teaching science, while below average/average for their own background knowledge for teaching science and confidence in teaching science. Across the science methods course, the pre-service teachers believed they had increased in all four areas, with this increase tending to reflect a whole unit increase across the five-point response scale.

Table 11.1 Pre-service teachers' perceived science teaching ability, comparing pre-test ($n=28$) and post-test ($n=32$) percentage responses

1. My own interest in teaching science is best described as	Not interested			Interested	
Pre-test	0	11	39	43	7
Post-test	0	0	22	34	44
2. My own background knowledge for teaching science is best described as	Limited			Extensive	
Pre-test	18	28	50	4	0
Post-test	3	9	31	54	3
3. My confidence in teaching science is	Not very confident			Confident	
Pre-test	4	39	50	7	0
Post-test	0	3	16	62	19
4. I am enthusiastic about teaching science	Rarely			Always	
Pre-test	0	4	28	50	18
Post-test	0	0	12	44	44

Table 11.2 Summary of pre-service teachers' reasons for increased confidence to teach science ($n=38$)

Category of reason	Percentage
How to teach science to young children	82
Science activities/resources/ideas	58
Science content knowledge	50
New views of science	10

11.3.2 Pre-service Teachers' Confidence to Teach Science

Pre-service teachers' confidence to teach science increased significantly over the science methods course. Mean total values (across the 13 items in the scale) for PSTE increased from 39.0 to 49.4 ($t=7.21$, $p<0.001$, $n=26$). As minimum and maximum values of PSTE range from 13 to 65, this equates to almost one whole unit increase across a five-point scale. The pre-service teachers tended to rank themselves as 'average' at the beginning of the science methods course, yet by the end had ranked themselves as 'above average'. These values are similar to those reported in the literature. The following authors found significant increases ($p<0.01$) in PSTE across their science methods course: Cantrell et al. (2003) from 46.3 to 53.6, Palmer (2006) from 42.0 to 53.0 and Watters and Ginns (2000) from 44.8 to 49.2. The modified PSTE scale had a high reliability (Cronbach alpha coefficient of 0.93), indicating the 13 questions were measuring the same construct.

Table 11.2 presents a summary of the reasons from the open-ended questionnaire (OEQ) the pre-service teachers believed they had increased confidence to teach science. Most responses from the pre-service teachers included more than one of the identified categories. Relevant comments from the pre-service teachers (PST) are presented to support these findings.

The majority of pre-service teachers (82%) believed that being shown how to teach science to young children was the main reason for their increased confidence. Being shown how to teach science included the use of engaging hands-on learning, letting children explore, integration across the curriculum, use of cooperative learning experiences and the importance of determining children's prior knowledge.

> Being provided with so many ideas to support science teaching, particularly in relation to where to start with very young children, and what sequence should be followed. I also have a better understanding of each of the science areas. [PST17_2008_OEQ_Q1]

Over half (58%) of the pre-service teachers identified the science activities, resources and ideas presented in the workshop as assisting their confidence to teach science.

> I have learnt so much within this unit and because of this my confidence has grown hugely. By carrying out investigations for ourselves each week, I was able to see how easy and fun science is and can therefore be taught. Everything that we have been taught can be used in the classroom and it is very exciting! I can't wait to teach science, and I used to not enjoy science through school. [PST6_2008_OEQ_Q1]

Fifty percent of the pre-service teachers mentioned science content knowledge as the reason for their increased confidence to teach science.

> I believe that my confidence has improved because I now have a stronger understanding of scientific concepts and explanations, and I know how to present them to my students. By making science activities more hands on and active, I am confident that children will be eager and willing to participate. [PST1_2008_OEQ_Q1]

A small number (10%) of the pre-service teachers mentioned the new views of science that they now had as a consequence of the science methods course as the reason for their increased confidence to teach science.

> Before I saw science as the science I learnt in high school and I knew I didn't understand it so I couldn't teach it. Now I know science can be adapted to everything and it can be done in a fun way. [PST26_2008_OEQ_Q1]

These results show that the pre-service teachers have not only increased their pedagogy, knowledge of activities that work and science content knowledge, but they have also increased the science PCK. Being shown what science to teach, how to teach that science and how to explain it to young children has not only resulted in increased confidence to teach science but an eagerness to move into the classroom and share science with the children.

11.3.3 Pre-service Teachers' Science Content Knowledge

Table 11.3 presents a summary of the reasons from the open-ended questionnaire the pre-service teachers believed they had increased science content knowledge. Most responses from the pre-service teachers included more than one of the identified categories. Almost two-thirds of the pre-service teachers (63%) believed the active participation within the workshops contributed to their increased science

Table 11.3 Summary of pre-service teachers' reasons for increased science content knowledge ($n = 38$)

Category of response	Percentage
The active participation within the workshops	63
Having science/engineering academics in the workshops	45
The modules	34
Doing the assignments in the course	13

knowledge. Additionally, 45% of the pre-service teachers believed having a science/engineering academic in the workshop assisted, while a further 34% commented on the use of the developed modules. Most responses from the pre-service teachers included comments that related to two or three of the identified categories, as illustrated below.

> I have gained a far better understanding about a wide range of ideas in the field of science through this unit, due to the hands-on activities along with discussion about the activities and investigations. [PST11_2008_OEQ_Q2]
>
> By the scientists coming in especially the first workshop [astronomy] it has cleared up a great deal of misconceptions I had about space. By me learning the scientific ideas I now feel more confident in teaching it to children. [PST3_2008_OEQ_Q2]
>
> There were many aspects of science that I did not fully understand before I started this unit. The modules, however, increased my knowledge and made me think about my misconceptions. I now also know that science is all around us and know what to teach and how to teach it. [PST9_2008_OEQ_Q2]

To determine the exact nature of the pre-service teachers' learning over the science methods course, their posters were analysed for content learnt. Table 11.4 presents a summary of the major categories of response (greater than 15%) from each of the four workshops where a science/engineering academic presented. In responding to what content they learnt, Table 11.4 shows that the pre-service teachers did not restrict their comments to just science content knowledge, but also to various pedagogical strategies, and learning how to apply a certain topic at the early childhood level. This type of response was present in all four workshops.

Reflecting on the astronomy workshop, 61% of the pre-service teachers stated they had increased science content knowledge relating to the phases of the moon, seasons of the year or day and night, while 47% stated they had become more aware of their own astronomy alternative conceptions. A large percentage (45%) of the pre-service teachers stated they had a 'better understanding' of the science behind the astronomy concepts as a consequence of the workshop. Further, 16% of the pre-service teachers mentioned they had learned about the place of alternative conceptions in the teaching and learning process.

> Grappling with the concept of the 'phases of the moon' stood out in this workshop. My knowledge of this concept is rarely challenged or even discussed. Having to tell the class how these phases work was both humiliating and immensely valuable. [The scientist] noticed my struggle and provided me with his 'scientific' understanding of how these phases operate. I was then able to ask questions, clarify, demonstrate and make mistakes in a 'safe' environment until I felt comfortable with my basic conceptual knowledge. … [I experienced] the value of having a 'real' scientist present. [PST26_2008_POSTER]

Table 11.4 Summary of content the pre-service teachers learnt from each workshop in which a scientist/engineer participated ($n = 38$)

Topic	Category of response	Percentage
Astronomy	Specific facts relating to phases of the Moon, seasons of the year, shadows or day and night	61
	Awareness of own alternative conceptions	47
	'I have a better understanding now'	45
	The place of alternative conceptions in teaching and learning	16
Forensic science	Every contact leaves a trace	55
	Uniqueness of fingerprints	47
	Misconceptions of forensic science in the media	37
	Early childhood application	37
	Procedure for taking fingerprints	29
Cleanliness	How soap works	74
	What soap and water molecules look like	34
	Using a literacy book to teach science	32
	3D mind maps	29
	Procedure for making a solar cooker	47
Solar energy	Principles of solar cooking	37
	Definition of sustainability	32
	The Sun as a source of energy	26
	Early childhood application	16
	Difference between conduction, convection and radiation	16

Reflecting on the forensic science workshop, the pre-service teachers commented on the principles of forensic science, the uniqueness of fingerprints, the correct procedure for taking fingerprints and alternative conceptions of forensic science presented in the media. Further, the pre-service teachers noted they had learned how to use the theme of forensic science in the early childhood setting, something they had previously thought impossible.

> The workshop really changed my thoughts about teaching early childhood students about forensics. Before I attended this session, I never would have even thought about bringing forensics into the classroom because when I hear forensics I just think about murders. I love the forensic bear hunt idea. It is very appropriate for young children and would help them learn in a very engaging way. This was significant to me as it challenged my ideas about forensics and bringing it into the classroom. [PST1_2008_POSTER]

In the cleanliness workshop, the pre-service teachers learnt about the process of how soap works and becoming more aware of the chemical structure of soap and water molecules. The pre-service teachers also believed they developed pedagogical content, commenting they had learned how to teach science through a literacy book and how to use 3D mind maps (Howitt 2009).

> [The] workshop allowed us to explore the extremely relevant science topics to early childhood education – cleanliness and hygiene. The concepts were integrated within the theme 'Mrs Wishy Washy' demonstrating to pre-service teachers the way in which scientific understandings can be made both engaging and meaningful through a literature context. [PST10_2008_POSTER]

Reflecting on the solar energy workshop, the pre-service teachers commented on a range of science concepts they had learned, including the principles of solar cooking; definition of sustainability; the Sun as a form of energy; and the difference between conduction, convection and radiation. They also commented on learning how to make a solar cooker. The use of solar energy as a theme in the early childhood setting was also mentioned.

> [I learned] the Sun is a free, natural source of energy. Knowledge of how to make use of the Sun's energy is becoming increasingly important for future generations due to our rapid consumption of fossil fuels. We can easily turn energy from the Sun into heat for cooking. We can use this knowledge in our classrooms where children utilize available materials to make their own solar cooker. [PST15_2008_POSTER]

Increased science knowledge is not simply a consequence of being presented with more scientific information. These results illustrate the interplay between learning through doing, while also having 'experts' to answer questions and the provision of materials (the modules) to obtain more information. This is further reflected in the pre-service teachers' responses to what content they learnt in the workshops where a science/engineering academic was present. Their responses were not solely restricted to science content knowledge but included science pedagogy and how to adapt science ideas for the early childhood classroom.

11.3.4 Teaching Science in the Early Childhood Classroom

Thirty-two of the pre-service teachers went on teaching practice. Of these, 28 (94%) stated they taught some science. Seventeen of these 28 pre-service teachers (61%) indicated they had used the modules to plan their science lessons: nine used the cleanliness module, five used the forensic science module, two used the day and night module and one used the solar energy module. Over half of these 17 pre-service teachers commented they adapted the ideas presented in the modules to their specific context. Comments on how the pre-service teachers applied what they had learned during the science methods course included the place of engagement and exploration, hands-on learning and multi-sensory activities, questioning, obtaining prior knowledge, small group work and using shared knowledge and ideas.

In planning their lessons, the pre-service teachers used the modules in various ways. Some relied almost entirely upon the modules, while others refereed to specific sections of the modules depending on the context of the learning.

> I chose aspects of the [forensic science] module and altered the activities to be age appropriate. The children … were engaged, motivated and immensely excited about the activities. Transferring the knowledge I learnt about forensic science and how to teach it to children proved effective. [PST1_2008_INTERVIEW]
>
> The cleanliness module really assisted my planning. I was able to base all my lessons around the module with ease. The children enjoyed the program. The module was easy to modify for this [4-year old] level. [PST2_2008_INTERVIEW]
>
> I incorporated several ideas from the cleanliness module. One of the most interesting experiences I had with the children was when I introduced them to the two mud activities

> [chocolate mousse and wet clay ideas from the module]. I [also] provided mud made from cornflour, water and cocoa [an idea not included in the module]. The children absolutely loved these activities as they had the opportunity to explore the materials,… discover science for themselves, and most of all, the experience was fun! [PST3_2008_INTERVIEW]

11.4 Discussion and Conclusion

This research sought to increase pre-service early childhood teachers' confidence to teach science through a collaborative approach between science/engineering academics and teacher educators to develop and implement science modules within a science methods course. Over the science methods course, the pre-service teachers increased their interest in teaching science, knowledge for teaching science, confidence in teaching science and enthusiasm for teaching science. The pre-service teachers identified a combination of reasons that contributed to their increased confidence to teach science: being shown how to teach science, performing science activities, having access to resources and increased science content knowledge. The method in which the modules were implemented into the science methods course provided opportunities for the pre-service teachers to engage in science that they might be expected to teach in the classroom. As Appleton (2003) reported, if this is accompanied with the pre-service teachers being shown why the science they are doing works in both the scientific and pedagogical sense, then they are likely to develop their science PCK. The carefully constructed science learning experiences presented in both the modules and science methods course assisted in the ongoing development of the pre-service teachers' science PCK.

Notably, the pre-service teachers did not consider science content knowledge to be the most important reason for their increased confidence. This supports the findings of Howitt (2007) who reported that science pedagogy and science activities were considered more important than science content knowledge in improving pre-service elementary teachers' confidence. Pre-service teachers value experiences that are directly transferable into the classroom. Thus, they value knowledge of science pedagogy, science activities and science content as a whole, rather than as discrete events. Learning to teach is not a discrete process, rather it is a complex, subtle and continuous process that requires different forms of knowledge (Wideen et al. 1998).

Pre-service teachers reasons for increased knowledge and understanding of science were attributed to active participation within the workshop where they experienced first-hand authentic science activities for the early childhood classroom; access to the science/engineering academics in the workshops to clarify points and ask additional questions relating to science content knowledge and to procedures related to activities; and access to the modules which had a wide range of information relating to activities, resources, science knowledge and integration. Many pre-service teachers considered the combination of all three factors to be integral to their knowledge of science. This further reflects the holistic approach of learning how to teach science

which pre-service teachers appear to require. This holistic approach is also supported when interpreting the pre-service teachers' content learnt from the workshops in which a science/engineering academic participated. Learning was not restricted to science content knowledge. Rather, the pre-service teachers recognized pedagogical content and application to an early childhood context. The results from this research highlight the holistic and integrated approach that pre-service early childhood teachers take in their learning. If this is how they are learning, then this should also be the approach to teach them within the science methods course.

The experiences within, and confidence from, the science methods course were transferred across to the pre-service teachers teaching practice. Over 60% of the pre-service teachers had used the modules to prepare their science lessons, with more than half of these being prepared to modify the activities within the modules for their own context. The modules had been used in the manner for which they were designed: as an adaptive and flexible tool for early childhood science teaching and learning.

This research has found that a collaborative approach between teacher educators and science/engineering academics to develop and deliver science curricula has assisted early childhood pre-service teachers to increase their interest, confidence and enthusiasm for teaching science, along with their science content knowledge. This approach to teacher education has increased the pre-service teachers' accessibility to science and encouraged the teaching of science within the early childhood classroom.

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