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Circles of Truth in Curriculum-making for Science in the Primary Classroom: Keeping in Mind Simplicity, Compassion and the 'Faded Green Textbook'

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DECLARATION

To the best of my knowledge and belief this thesis contains no material previously published by any other person except where due acknowledgement has been made.

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

Signature: Alisa B. Tassell.

Date: March 31, 2017

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I would like to thank all those from whom I have gathered insights from my lifetime of living as a child, student, parent and teacher that have enabled me to bring together remnants and reminders of our interactions into written words that may support primary teachers to kindle the light of science to shine in their hearts and minds as they teach and learn about science together.

To dwell in the memories of what I have shared with you has been an honour and indulgence that has helped me understand the moments of good and virtue in our relationships and ones that bring sadness and sometimes regret—they all contribute to the rich tapestry of life that underpins my inquiry.

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ABSTRACT

My inquiry revolves around the purpose, values, compassion, responsibility and faith that have accompanied me as a curriculum-developer re-imagining a science curriculum for primary teachers and their students. It is a human science inquiry in which I reflect and interpret the 'lived experiences' of my lifetime as a child, a student, a teacher, parent and grandparent whilst looking for a possible answer to my question about the shape this curriculum might take and how it might be communicated with primary teachers in a simple and thoughtful way which might support them to overcome barriers sometimes felt when teaching science.

Often my inquiry returns me to experiences of change as a secondary science teacher when I was called on to reframe many of my ideas of teaching, particularly my teaching of science. I often found myself drifting without any sense of purpose or direction during this time and to quell my need for guidance I began writing my own science curriculum for Years 7 and 8 using guiding principles from my teaching of science.

These curriculum attempts are revived in *A Science Curriculum for Primary Teachers and Their Students* (aSCuPTaS), a curriculum that grew from my living practices of science teaching involving many cycles of action research. My thesis is that living inquiry has resulted in a science curriculum I find trustworthy for primary teachers and their students in Australia—much of the content of my writing pertains to the evidence I find to support my trust in primary teachers and my living theory of curriculum-writing that has evolved, especially the way energy and values can be seen to flow.

aSCuPTaS is the 'gift' I leave from my inquiry in my hope it might add to our understanding of the possibilities for a science curriculum if it evolves for the specific purpose of guiding generalist primary teachers to bring the light of science to shine in the hearts and minds of their students. I believe the strength of aSCuPTaS has come from the mutual respect and faith that we, as curriculum-writer and teachers, can bring together through our sharing of the responsibility for the children in our care, is more than either of us might do alone.

CHAPTER 1
THE WORD 'CURRICULUM' HAS AN UNCOMFORTABLE FEEL

My need to do something rather than nothing when confronted
by the suffering of another… Ann Chinnery (2017)

When talking with friends I am often asked why I have written a science curriculum for primary teachers and spent so long on this inquiry—my answer is steeped in emotion, its expression somewhat pretentious, but my need comes from deep in my heart. Quite simply, I want to share some of what I learned from teaching secondary science from the 1970s to the first decade of this century so that others negotiating change might find the path less rocky. My dogged search to develop an understanding of the road I travelled so that I might support primary teachers to introduce more science into their classrooms has led me to revisit many experiences in the hope that what I came to know and understand might help reclaim the humanity of primary teachers and bring back the reverence they once enjoyed because of the role they play in educating children.

My desire would ultimately manifest itself as a curriculum that could encourage generalist primary teachers to add more science into their teaching practice. It lies on my desk now—*A Science Curriculum for Primary Teachers and their Students* (aSCuPTaS)—written in the first decade of this century, adopted for a time in a small school, perhaps accumulating dust now, for things have changed—again.

This thesis explores ways of lowering the resistance of many primary teachers in Australia to teaching science by questioning how a curriculum designed specifically for them might remove the barriers that cause their resistance. It is for primary teachers who find bringing science into their curriculum beyond their capacity, and feel unable to activate their energy for it despite its mandatory inclusion.

There is much discussion about who should teach primary science in Australia. I come back to this idea later in my thesis, but throughout my inquiry I remain strongly in support of generalist primary teachers retaining this role. In describing *Five Challenges for Science in Australian Primary Schools,* Simon Crook and Rachel Wilson express their opinion that right now,

> there are some wonderful primary teachers out there who openly admit they need help with teaching science. However, national, state and school structures currently conspire to make this more difficult and less enjoyable than it should be. (2015)

It is on these "wonderful primary teachers" my inquiry is focussed because I have faith and trust they can bring many opportunities for science learning to their students if they, the teachers, receive thoughtful and caring support. I believe some primary teachers have been and still are 'suffering' because of the change in the emphasis of science in their schools and a science curriculum specially designed for them might be my way of "doing something rather than nothing" (Chinnery, 2017) to encourage those still reluctant to take responsibility for science in their classrooms.

I open with a story of a beginning, the first glimmers of aSCuPTaS. It is perhaps not the beginning really—I can truthfully say neither where this story began nor where it might end. I refer to the very first forms of aSCuPTaS as PaSCuPTaS—pre-aSCuPTaS.

The Birth

PaSCuPTaS *is a curriculum that flowed from my heart. I was a teacher retiring from teaching science in secondary schools—elated, excited, renewed, full of hope for the future but exhausted—exhausted by the information overload experienced by teachers, particularly since the late 1980s. It was my response to the unguided nature science teaching became for me at a time when I should have* been experiencing hope, and the possibilities that would come with changes to our thinking about education.

The seeds of PaSCuPTaS were planted whilst I was teaching mostly Year 7 and 8 science classes in the 1990s and early 2000s—searching desperately for a way to make sense of the eclectic collection of ideas, many relating to the pedagogic nature of teaching, others to the content and purpose of science teaching, that at first trickled and then began to flood into my secondary teacher's consciousness. As the flood broke from its banks many teachers were dragged from the land, lost sight of the shore and drifted in one direction and then another as the torrent took them, as the 'known' of education was translated and transmitted by interpreters to those who received messages one after another that told of different hope on different shores. We seemed lost in the way Louise Mabille writes as, "Being lost in the sea of shifting impressions is precisely what threatens in our awkward age [of education]" (2012, p. 58) lost without any reassurance from the 'faded green textbook' and 'trusted syllabus' that once accompanied me during my early days of teaching and will become familiar notions in my inquiry. The words we uttered were often unheard, words that called for help, explanation and purpose, and for time—time to think and time to act. Some closed their ears and heard nothing, others dutifully succumbed to the ideas of the "known" through an interpreter who added his or her definitions of what they should do (Palmer, 1983/93, p. 56). Others, like me, hovered in uncertainty.

Whilst I was still teaching I found a space to listen and question, for a short while, my own thoughts. In that space the seeds of an idea were planted, began to germinate and then bear fruit, embryonic fruit. This embryonic fruit found more space to grow when I finished teaching—it grew into PaSCuPTaS, the curriculum I had dreamed of when I was teaching, a science curriculum for a Year 7 and 8 science teacher and her students, although, because of the empathy I felt for primary teachers, it masqueraded as a curriculum for them. But, in truth it *was based on the knee-jerk reaction of an exhausted secondary science teacher harbouring bittersweet memories from a long period of change, memories of pleasure tinged with sadness.*

This story tells of the birth of PaSCuPTaS. It emphasises the fear I developed when left to drift during a time when teaching was changing dramatically. It accentuates my need to grasp something, anything that would help me feel connected to the previous world I had known as a science teacher. The embryonic fruit I speak of was a set of principles that grew from living inquiry (Meyer, 2008; Whitehead, 1985, 1989, 2008) and represent the educational theory that guided my last years of teaching and helped re-establish my feeling of connectedness and purpose. My new world consisted of the familiar and the new, a blending of horizons. "To acquire a horizon means that one learns to look beyond what is close at hand – not in order to look away from it but to see it better" (Gadamer, 1975/2004, p. 304). I extended my understanding, acquired a new horizon of what it means to teach and the responsibilities it brought to being a science teacher during this time.

To write PaSCuPTaS was cathartic, liberating—it left me with a sense of altruism. I was practising selfless concern for the wellbeing of others by acknowledging my empathy for primary teachers as the status of science in Australian primary schools was changing, with a practical response—leaving something more tangible than the dreams I had when teaching, "doing something rather than nothing" (Chinnery, 2017).

But in its early version PaSCuPTaS was only posing as a curriculum for primary teachers, really, it was a curriculum for me. In its writing, "I worked towards shaping that [new] world in my own image," (Palmer, 1983/93, p. 4) without allowing for the special needs primary teachers may have when including science into their curriculum. My altruistic move of writing PaSCuPTaS in its very first form, based on my experiences as a secondary teacher, was a promising but emerging form of aSCuPTaS as it appears now in the Appendix.

PaSCuPTaS has matured and grown from its conception. I have developed a more authentic understanding of my reactions as a teacher during a period of change and now recognise with greater clarity the common ground I might share with primary teachers, and the different ways change has affected primary teachers and secondary teachers because of the prejudices our "fore-understandings" bring to our teaching (Gadamer, 1975/2004). Many of my early ideas have remained in aSCuPTaS but the truth and relevance of their presence is more understood. My motivation to write aSCuPTaS was genuine and remains unchanged. It was my hope that aSCuPTaS could assist primary teachers to gain more confidence and expend less energy when negotiating the introduction of science into their classrooms—a change I perceived as valuable, but something unfamiliar for many primary teachers.

In my inquiry, I examine closely the development of aSCuPTaS so that it becomes more inviting for the primary teachers I have grown to understand. As my inquiry unfolds I take the reader on parallel journeys. One is centred on my 'lived experiences' (van Manen, 1990) as a secondary science teacher, and how I came to understand a long period of change in education, particularly changes to science education. The other is my journey to understand primary teachers and what it might be like to respond to the mandated inclusion of science.

These two pathways enable me to bring together two prevailing values—the value I place on science, particularly the value of an increased emphasis on science in primary schools, and my value of teachers, above all teachers in primary schools. PaSCuPTaS as it first flowed from my heart changed through these explorations, not much, only a little, but in a way I hope listens more closely to the hearts of primary teachers. My journey does not forget the children that are loved by me and their teachers, our future, and the needs for science to remain as something of wonder for them, a curiosity on which to deliberate, as opposed to science "where we are distracted by preparing children for the so-called 'real world' of workers and economic growth" (Seidel & Jardine, 2014, p. 134). I now understand we are three players—curriculum-writer, teacher and students. As aSCuPTaS evolved, the interacting and intersecting roles of these players became more significant in arriving at a communal truth, one that is not yours, or mine, or the children's but comes from us all (Palmer, 1983/93, p. 55).

My inquiry drifts in time and place and emotion—from now to the past to the future—to classrooms, childhoods, moments of joy and sadness and hope and despair, all in the cause of understanding what helps me know aSCuPTaS is born from truth, and understanding and compassion.

FRESH FROM SUMMER'S WARMTH

To write a primary science curriculum was not my first choice as a way to encourage primary teachers to embrace science teaching, but the experiences I revisit channelled me to this path.

> Accepting their place
>
> *I watched as they arrived in my secondary science classes—a breath of fresh air to the stark and unwelcoming laboratory—fixed benches, uncomfortable stools—legs dangling. I looked forward to their arrival, Mae and Molly, Lily and Lian—fresh from summer's warmth, full of expectation for a new stage of their schooling.*
>
> *Their experiences of primary school were mixed—state schools, independent schools, home schooling and combinations. Each year one or sometimes two from a local Steiner school, "Receive the child in reverence; educate them in love; let them go forth in freedom " (https://www.tarremah.tas.edu.au/about/our-philosophy). All now at an independent girls' school, clothed identically, momentarily unknown to me and vice versa—could I continue to honour Steiner's fine words?*
>
> *A hint of disappointment washed over me as they talked about science. For some, their science lives were filled with wonder and awe, for others, science was dreary—projects, worksheets, information from books, the Internet. Some had little to be remembered. A number spoke confidently about science, others had gathered words without meaning.*
>
> *Some seemed 'safe' and confident in this space of science, others scrambled to hide their frailty and uncertainty. Many had strong opinions about their*

relationship with science—sadly they seemed to either love science or were already expressing feelings of boredom, giving up hope, accepting their place.

I pondered the inconsistency, I began to think about what I expected, what I saw as the purpose of primary science. Each time my ponderings took me to soft feelings of birds and stars, of seas with fish and seeds that lived, of worms that wriggled and dinosaurs. I thought again and heard small voices ask of tides and time, of wheels and bikes, of boats and baths and how and why, what if and wow!! Maybe I dream?

My words drifted from purpose to content, my mind to attitudes and opportunities, my mind muddled from the inextricable links that began to dawn—purpose, content, opportunities and attitudes—and the effects these might have on bringing more consistency to the new brood who came each year to science.

My conscience was troubled by these memories. In my early days of teaching, when science was not a compulsory part of the primary curriculum, I assumed students coming to secondary school had little formal science education (Angus, Olney & Ainley, 2007). As science became more evident in primary schools, I was beginning to see students were not the clean slate I once thought—they came with history and preconceptions. Their varying degrees of knowledge I could accommodate, their strong preconceptions of science I found more disturbing—what it is, what you do and where you stand in the hierarchy of science students. These were not so easily accommodated and were probably more critical for maintaining a future interest in science. Options to science learning were closing prematurely, in a way I had seen more often in mathematics classes. Sadly, students' prejudices were limiting their horizons, excluding opportunities for extension, for merging old and new to open wider vistas (Gadamer, 1975/2004).

The literature at the time supported my observations of inconsistency (Rennie, Hackling & Goodrum, 2001; Angus, Olney, Ainley, Caldwell, Burke, Selleck & Spinks, 2004; Angus et al., 2007) and this continues to be a concern (Thomson, Hillman, Wernert, Schmid, Buckley & Munene, 2012; Australian Science Teachers'

Association [ASTA], 2014; Thomson, Wernert, O'Grady & Rodrigues, 2016). Inconsistency is usually identified by the amount of time primary children spend learning science, and by their achievements in science when tested at the international level—both factors are easily measured. These measures are not quite like my notions of inconsistency which were measured by what I saw and heard and were dependent on the inextricable links I was beginning to see between purpose, content, opportunities and attitudes.

There was speculation that the lack of clear guidelines and the difficulty of their interpretation by primary teachers might be a contributing factor to the inconsistency of science learning in Australian primary schools despite curriculum guidelines being available in all Australian States (Rennie et al., 2001; Skilbeck & Connell, 2004; Dawson & Venville, 2006). It has been suggested that even if curricula are written to support current ideas about science education these ideas are not necessarily easily translated into practice. Denis Goodrum writes, "There is a considerable gap between the intended curriculum as described in the various [Australian] curriculum documents and the actual curriculum experienced by these students" (Goodrum, 2006, p. 31). This was my cue to do something rather than nothing. I was beginning to formulate a possible answer that came from my experiences in secondary schools. I went in search of the 'faded green textbook' and the syllabus I had so sorely missed (see Chapter 2).

At this point I would like to introduce the form much of my reflective writing about my experiences has taken. I see my pieces of writing are often like confabulations, a word my mother used to say to describe my childhood stories. I liken them to John Berger's "confabulations" written in his notes towards the end of his life. He says,

> After I've written a few lines I let the words slip back into the creature of their language. And there, they are instantly recognised and greeted by a host of other words, with whom they have an affinity of meaning, or of opposition, or of metaphor or alliteration or rhythm …
>
> So I modify the lines, change a word or two and submit them again. Another confabulation begins.

> And it goes along like this until there is a low murmur of provisional consent. (2016, p. 7)

I write now of the experiences that led to my curriculum-writing despite the word 'curriculum' leaving me with a sense of discomfort.

Lost Hope

I began in hope
To write a science program for primary teachers
To publish—to leave something
Behind
From my years of secondary science teaching.

I began in hope
To use
The science curriculum from my state
Kindergarten to Year 10.

I began in hope
To read
Performance criteria, strands, terms, assessment guides
Examples, activities—
Two hundred pages.
I began in hope
To plan my own
Sequence and scope
So many hours—of work.

I asked in hope
Where is the science to teach?

Disillusioned, defeated, abandoned
I left in hope
Of finding another way.

This science curriculum
Was written in haste
To replace the one before.

I have hope

This won't continue.

These experiences helped me understand the difficulty of interpreting the dense and confusing nature of one of the science curricula available to Australia's primary teachers. But there are many books and science programs available to primary teachers in Australia. *Primary Connections* (https://primaryconnections.org.au) is perhaps the best known—a science program introduced in Australia in 2005 and based on the 5E Instructional Model created by the Biological Science Curriculum Study ([BSCS}, https://bscs.org). It is offered as a solution to some of the problems primary teachers experience with science teaching and has been used successfully by many. My vision was to write something that might allow more freedom than a specific science program and there is a certain logic and simplicity to my decision to write yet another curriculum.

My reasoning moved from the difficulties I had making many changes in my secondary school practices, to the difficulties primary teachers were experiencing as science was being given a more substantial role in the primary curriculum. I valued the addition of science in primary schools and decided to write a science program for primary teachers using the curriculum in my State. I found it too difficult to follow and there were already plenty of books and programs available to primary teachers in Australia. This logic led to my decision to write another science curriculum.

There may have been logic and simplicity but there was also naivety about my choice. Even the word 'curriculum' had an uncomfortable feel for me—something hallowed, something remote, something barely filtering into my awareness for most of my career. There had always been a syllabus, a brief statement of the contents of a curriculum, and the 'faded green textbook', although this had gradually morphed into something more glorious—glossy, coloured, online with web-links, e-assessment and e-lessons. The curriculum obviously has a very strong role in the design of textbooks and is always acknowledged—in earlier years linked to the curriculum of each Australian state but now linked to the *Australian Curriculum: Science* (Australian Curriculum and Reporting Authority, [ACARA], 2017).

I was not tempted by the notion of a curriculum that might become like the one I had found so difficult to follow, but by the idea of a re-imagined primary science curriculum, an idea suggested by Russell Tytler (2007). I am not sure my imagination would take quite the same path as Tytler's, although we shared many ideas. What I imagined has many qualities of current science curricula in its sensitivity to the needs of students but is written for their teachers. It is a curriculum I hope speaks to them without the need for interpretation through an intermediate program or text book—a curriculum for teachers, a curriculum for freedom—for those who want to take responsibility for science learning themselves. My re-imagined curriculum would take me on a journey that, even before I began its writing, challenged my preconceived ideas of a curriculum. These prejudices or pre-judgements of which Hans-Georg Gadamer (1975/2004) writes, would "open up as well as constrain" my inquiry (Mabille, 2012, p. 61) and give me a sense of comparison and measure for my interpretations.

PaSCuPTaS, the beginning of this re-imagined curriculum, may have been truthful to me but I had little evidence to believe my personal truth as trustworthy in a wider arena. As one teacher in one classroom with one class I might have risked responsibility, knowing that the eyes and ears and reactions of my students, colleagues and/or parents would soon tell me if they found little truth in my decisions. This truth came to me because for many years I had consciously and unconsciously introduced ideas of contemplative practice into my classroom. I came to understand this as 'action research' when through professional learning in the 1990s I was introduced to the notion of action research and later read the work of Jean McNiff (1988/92) in her book *Action Research: Principles and Practice* with a foreword by Jack Whitehead. But as a secondary teacher with no background in curriculum, and writing for an audience of primary teachers, I was in a vulnerable position—there was a need to find more than my truth of PaSCuPTaS before it could fly as aSCuPTaS.

My dream of a re-imagined curriculum for Year 7 and 8 remained, but my hope had drifted to primary teachers—a hope my dream might help remove the barriers of their resistance to science teaching and help generalist primary teachers find the confidence to teach science. I believed my experiences in secondary schools would help me do this—experiences that led to my changing understanding of the purpose of science, the impact change can have on teachers and the place of a curriculum.

Secretly, I was quietly confident about this role of curriculum-writer even though primary teaching was not my profession. Neither was I a curriculum- developer or expert researcher and my ideas emerged from a secondary rather than primary perspective. After all, this curriculum was not to be so much about primary teaching but about communication and change and the barriers that might appear if these are not addressed with sensitivity. These ideas of communication and change are more universal and I could already imagine a science curriculum that might be used by primary and early secondary teachers to support changes in science teaching.

But perhaps the truth of why I so readily assumed the role of curriculum-writer was because I understood and valued the greater emphasis on science in primary schools. I felt responsible for finding a way to encourage primary teachers to embrace this change. When change is involved I believe it is the responsibility of those who see the advantages of it to find how it might be done in an ethical and principled way. I am one of those and want to acknowledge my responsibility by searching for a possible way of achieving the changes to primary science education through the words of a curriculum.

My words describe the deep responsibility I felt for writing aSCuPTaS and for the primary teachers who might make the change happen. I hope it is a curriculum that takes into consideration primary teachers' strengths as well as the reasons that might underlie their reluctance to teach science—a curriculum that acknowledges and might be more mindful of the heartache that change often brings and the toll this can have on those involved. One of my prime focuses as curriculum-writer is on the health and wellbeing of primary teachers as they teach science. Of course, this is not to say I do not support one of the principles on which the *Australian Curriculum* (ACARA, 2017) is written, "the prime focus is on students, their wellbeing and personal development" as stated in the design principles in the *Review of the Australian Curriculum* (Donnelly & Wiltshire, 2014, p.82).

I believed that as curriculum-writer, if I considered the wellbeing and personal development of the teachers working with this science curriculum, then the wellbeing and personal development of their students might follow—the "gap" Goodrum (2006) spoke of and the inconsistency I observed might be diminished.

As a science teacher, I might say this is the 'cause and effect' hypothesis of my inquiry, although I will not be measuring this in a traditionally scientific way. To measure such things as wellbeing, personal development, gaps and inconsistency in traditional ways is unrealistic and lead me to the alternative methods. My measures are those of Gadamer (1975/2004, p. 303) who writes of "the horizon of the past, out of which all human life lives, and which exists in the form of tradition, is always in motion". My measures would come from appraising the motions of change.

A ROAD TOWARDS MUTUAL TRUTH

The early part of this chapter tells of my reasons for this inquiry and how my purpose has become one of searching for the truth of aSCuPTaS that emerged from my first attempt at writing a primary science curriculum, PaSCuPTaS. The truth in the way of Parker J. Palmer (1983/93, pp. 47-58) and affirmation of that truth through deliberation on my changing horizons (Gadamer, 1975/2004) become central to my inquiry. I speak of the road I follow to find not my truth, not that of primary teachers and not that of their students but the mutual truth that emerges from our hearts.

I begin by writing,

A place for heart and brain

I have a place in my heart
For teachers—for children—for science
And focus my eyes on primary science
First science—small seeds of science.

Embryonic
Waiting for nurture—for wonder
To burst out—of their earthy place
Where possibilities linger
As seeds prepare—to emerge

And share a part of their darkness.

But frail—in those early years
Of struggle with winds that blow
Sun that dries
Insects—snails
And rabbits
That claim their dominance.

Let's find a place
A place where sun—and water
And gas that circles our planet Earth
Can play their magic—and bring to fruition
These vulnerable seeds—of science.

In the way and the warmth of
Teachers.

I have a place in my brain
For teachers—for children—for science
And let my heart and my brain
Play together
To bring shelter
To teachers.

To primary teachers
Whose hearts and brains
Bring other ways—sometimes
To show what they are offering.

Ways that offend—from time to time
And challenge
The minds of others.

Of the meaning of science
Of the purpose of science.

Others—who take offence
Don't understand—at times
The good they might bring
These wayward hearts and minds
And ask to tend to the seedlings
Themselves.

It is not my way as I open my heart
As I open my brain
And weave together
The memories of experiences
To my offering of rain
To ease the pain
Of uncertainty.

And bring hope
That comes from purpose
From confidence
In their capabilities.

To give a space—of energy
A space of community
Where teachers share with those they teach
A growing love of science
In a special way
Nourished by the hearts and minds
Of those who find a space of belonging in this habitat.

This writing represents the purpose and intentionality of my inquiry. aSCuPTaS reflects my way of 'doing something rather than nothing', the words of Ann Chinnery (2017) spoken on a short video-clip featured on the staff profiles of Simon Fraser University.

But Chinnery (2017) and Gert Biesta (2013/2016, p. 21) share words from Emmanuel Levinas (1985, p. 101), "I am I in the sole measure that I am responsible". This theme of responsibility flows through my inquiry and has significant consequences for teachers in training. Likewise, life affirming energy with values that carry hope for the future of humanity (Whitehead, 2008) become an important undercurrent of my work. If the energy and values I bring to my inquiry flows from me to the teachers I write for and from them to the students they teach and vice versa, can be sustained, then aSCuPTaS, as a notion of a primary science curriculum, will continue to live. Like the energy flow of any biological system, dependent on our sun, if we lose our faith in the values of aSCuPTaS this energy flow will cease. Fortunately, unlike our sun, aSCuPTaS is only one of the stars that might become our source of energy.

Later in this chapter I outline my research questions and why I hope my use of a human science methodology may reveal why I have brought a science curriculum to primary teachers which could differ significantly from other curricula, and be more attractive to primary teachers. This chapter shows my blending of methodology and method from the human sciences in ways that helped me understand what cannot be discerned through the methods of science I have been more familiar with. In this chapter I invite readers to keep company with the aSCuPTaS document found in the Appendix.

My explorations in Chapter 2 lead me to identify the differences and similarities between the changes to which primary and secondary teachers have been exposed, especially in science, and to understand the challenges this has brought. One focus of this chapter is on my colleagues in the secondary school where I taught. Questions emerge from narrating what it was like to live in this time of change, and why I saw change as hope when many of my colleagues, particularly in the science area, remained blinkered. In this chapter I also begin to make my way into the hearts of primary teachers and in a smaller way into the hearts of their students. I return to my direct and indirect experiences with primary teachers and begin to reflect and wonder about the differences between primary schools and secondary schools and the teachers who inhabit these vastly different environments. I explore why I believed many of the perceived difficulties primary and secondary teachers are experiencing with science teaching might be attributed to an unintended lack of mindfulness for those who practise the changes and how this might be reconsidered.

Chapter 3 is lengthy—but necessarily so. I revisit the set of principles I used to guide my teaching because of what I saw and heard. Through my writing, I recognise that when I developed these principles I was acting as curriculum-writer, because there was no curriculum like the one my vision called for, as well as classroom teacher. In this chapter I question each of the principles, why they grew to underpin my teaching practice, how they might apply to primary teachers and who—curriculum-writer or teacher—might take responsibility, or whether shared responsibility might be more appropriate.

I am not sure I can totally achieve my purpose in writing Chapter 4 because I do not think it is possible to understand completely the subtle intricacies and connections between pedagogy, purpose, opportunity and content. In Chapter 4 I talk of the debate these ideas raised for me and how through reflective practice I found resolution, at least for the moment. The ideas began as a slow trickle and grew to a wild torrent. I ask many questions about the need for pedagogical change, the 'big ideas' to be asked about pedagogy and how to meld big ideas with the day-to-day pedagogical decisions. I question how much as a curriculum-writer I can speak of these ideas without encroaching on the independence of teachers by asking too much or too little of them whilst also accepting my responsibility to the children they teach. I ask many questions about responsibility and the interacting roles of curriculum-writer, teachers and the children we are both responsible for.

Chapter 5 returns me to a time when I worked with a small group of primary teachers. Part of my role was to support them to transform their science teaching from one that had become strongly associated with the social sciences to one that had a greater focus on science. As I played this role I came to understand it as one of illuminative evaluation (Parlett & Hamilton, 1972), an invaluable, unplanned opportunity but one perfect for looking at aSCuPTaS in practice and searching for further truth that aSCuPTaS could serve its purpose and remove some of the barriers primary teachers might feel about teaching science. It gave me a space to review the prejudices I brought to aSCuPTaS that may be irrelevant in the primary situation and to make further modifications as my horizons became more encompassing of primary teachers.

Finally, in Chapter 6 I look at why my re-imagined primary science curriculum might bring the light of science to shine in the hearts and minds of primary teachers. I consider how its birth as a child of freedom and faith has made it different from other curricula for science, whether fidelity is ever possible in such a thing as aSCuPTaS, and whether aSCuPTaS is forever, or is, as Rosemary

Radford Ruether says, "[When] meditating on the profound interconnectedness of life and time, we might remember that our bodies each one are also re-cycled, like our garbage, like our breath," (as cited in Seidel & Jardine, 2014, p. 135). Like our bodies, I hope that when the time comes the ideas of aSCuPTaS might be re-cycled, provoking new and perhaps different thinking about science teaching in primary schools, not be shelved and forgotten. My wish is that aSCuPTaS can continue as an energy that breathes knowledge, compassion and possibility into science teaching in primary schools.

AN ANSWER UNDER-WRITTEN BY TRUTH?

My purpose in this inquiry is to pursue the trustworthiness of aSCuPTaS, because it is a dream that emerged from my experiences as a secondary science teacher, using methods foreign to those that permeated my thoughts from a life so closely connected to science, methods that would search for its truth. Truth I hoped would help free primary teachers from some of their uncertainties of change—changes to the nature of science learning in their schools. Palmer writes,

> Truth requires the knower to become interdependent with the known. Both parties have their own integrity and otherness, and one party cannot be collapsed into the other. But truth demands acknowledgement of and response to the fact that the knower and the known are implicated in each other's lives. (1983/93, p. 32).

aSCuPTaS is the child of PaSCuPTaS, a pre-aSCuPTaS notion I supposedly wrote for primary teachers but it was only a beginning, a subjective response, truthful to my needs, a personal truth. In this inquiry, I have searched for a more encompassing truth in my reincarnation of PaSCuPTaS as aSCuPTaS, initially grown from assumptions about Palmer's 'knowers', primary teachers, without fully understanding the need for my interdependence with these teachers. To do this I have become both "a guardian and defender of the true nature of the object" (van Manen, 1990, p. 20), namely aSCuPTaS, by returning to its pre-birth experiences, my traditions, the prejudices of which Gadamer (1975/2004) speaks.

But my traditions would not be the only ones under scrutiny, for the truth of aSCuPTaS lies not only in my domain but in the mutual melding of mine with that of those for whom I write, primary teachers, and the new horizons this might bring.

To return to these experiences gave me space to pause and reflect on the source of the possible answers to my research question. What might a science curriculum for primary teachers look like if it is designed to meet their needs, is it accessible to these teachers, does it makes the teaching and learning of science manageable in their context and does it support them to write science experiences for their students in the 21st Century? My response is aSCuPTaS. But there are many questions I explored before I could acknowledge aSCuPTaS as the science curriculum of my research question—a possible answer but one underwritten by truth. The all-embracing questions have become: why does aSCuPTaS look this way, and is aSCuPTaS able to create a relationship of truth between the curriculum-maker, teacher and students?

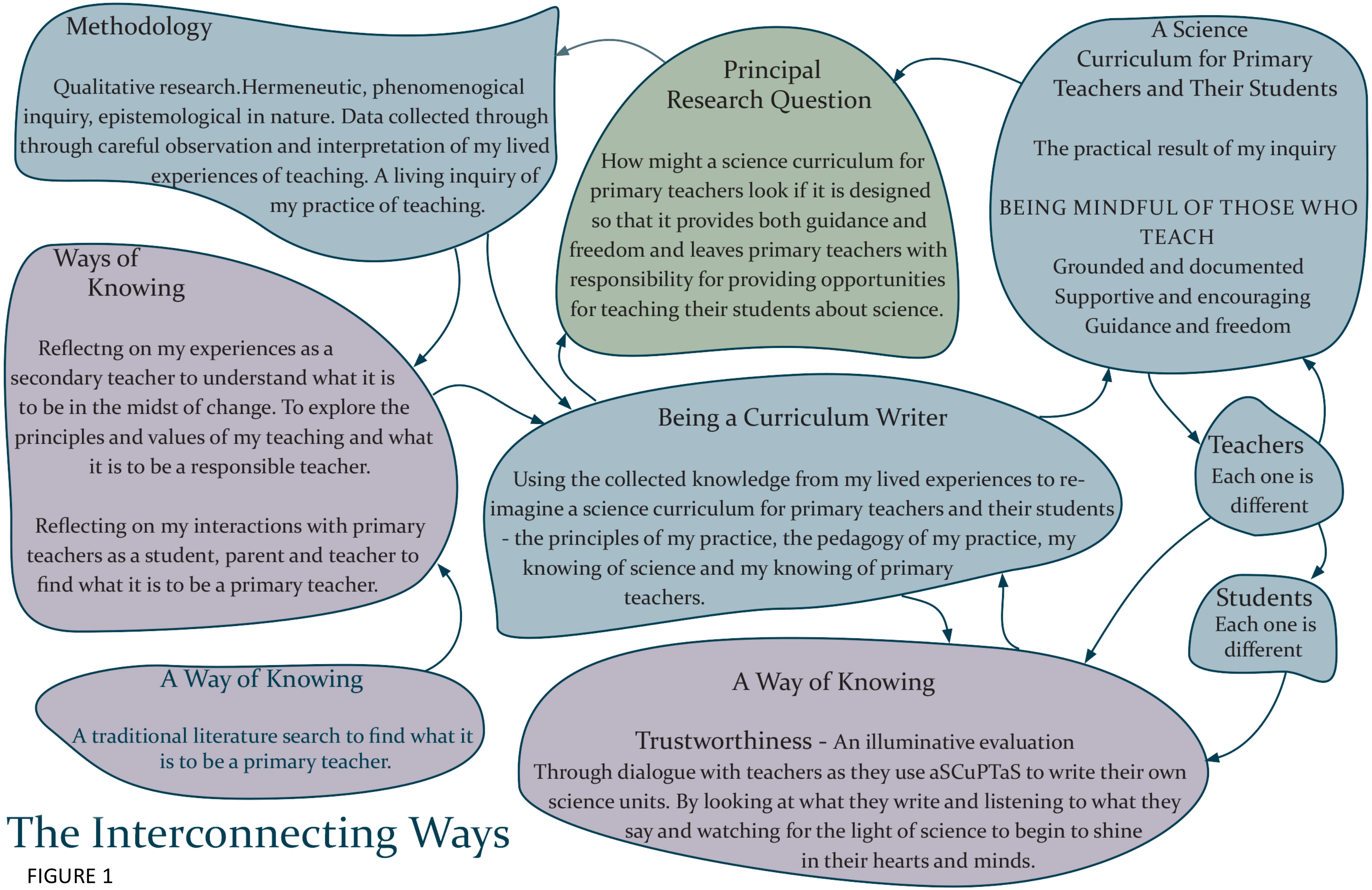
The possible answers to these questions evolved in three distinct stages I have written about in a relatively linear way. In reality my journey and that of aSCuPTaS have not been linear. Whilst I think of the subtleties of the changes I made from PaSCuPTaS to aSCuPTaS as being comparable to evolution through natural selection (Darwin, 1859/2003), each new form it has taken is perhaps better represented by Ralph Waldo Emerson (1841) as an "ascension of state, such as can be represented by metamorphosis, — from the egg to the worm, from the worm to the fly". Each new step has taken me to another platform of 'lived experience', caused me to reconsider my understanding in fresh light, to backtrack, refocus, reconsider and rewrite. In many ways, my inquiry has been about finding

> what is crucial is the process of identifying and linking the alien with the familiar information, selectively focussing the interpreter's search for new perspectives. This depends on his enthusiasm to be open to new possibilities. (Regan, 2012, p. 9)

"The alien" is teaching science in primary schools. "The familiar" is our mutual experiences of changes in education. The way we experience change and the feelings this brings with it make us resistant to change if our experiences were uncomfortable. I use my experiences with change to help find what might have induced primary teachers' reluctance to teach science, to find how the negative notions of change can be smoothed and perhaps reduce primary teachers' reluctance to include science in their curriculum. I believe they are the ones best able to do this, so my responsibility has been to find a way of linking the alien and the familiar to reveal new possibilities. Whilst I do not share the specific experiences my primary colleagues have had with change, our common experiences help my understanding of what might underpin our journey towards a mutual truth.

The methods I have used increased my capacity to do this. They have involved cyclical patterns of data collection, interpretation and application. My data comes from interpretations of my own experiences, with some supplementary data from other sources. For most of my inquiry I am both subject and interpreter. Writing has become a central part of my inquiry, not only as a form of communication but as a chance to understand a range of experiences that might impact on the science curriculum I have written. It has given me opportunities to measure my thoughtfulness, see more clearly and show me something (van Manen, 1990, pp. 127-133) but it has also led to much rewriting as what I find from one stage causes me to rethink previous stages before moving forwards again in the true nature of human science research.

To describe the process of my inquiry I have included two diagrammatic maps. Figure 1. *The Interconnecting Ways* on the following page presents an overall picture of the interconnecting flows of my inquiry and relations between the different aspects. Figure 3. *More Questions to Ask* in Chapter 5 focuses on the more specific texts and interpretations and how these contributed to my primary science curriculum and emerging ideas about curriculum writing.



The Interconnecting Ways

FIGURE 1

PATHWAYS TOWARDS OPENINGS

The philosophical framework of the methodology I use is hermeneutic and phenomenologically based in "human science approaches rooted in philosophy" (van Manen, 1990, p. 7). This methodological approach enables us to find out what it is like to be human and recognises the knowledge that can be gained from reflection and interpretation that involves writing, rewriting and the reforming of many of ideas. These opportunities were to help me understand why the traditions I brought from my living theories (Whitehead, 1985, 1989, 2008) resulted in my writing PaSCuPTaS in a very 'secondary teacher orientated way'. At this stage I was somewhat constrained by the kinds of biases that Gadamer cautions us about when we are operating in "pre-reflective" conditions of our 'lived experience', when our biases are controlled by prejudice. I found that, according to Gadamer,

> pre-reflective understanding is not necessarily unreliable or erroneous. Rather, pre-reflective understandings [prejudices] "are biases of our openness to the world. They are simply conditions whereby we experience something—whereby what we encounter says something to us. (1976/1977, p. 9)

My secondary school teaching biases, those that resulted in my beliefs of what should be included in a curriculum designed for primary science teaching, guided my writing of PaSCuPTaS. Yet they opened the means to reflect upon them in fuller awareness and give me understanding and more clarity about why PaSCuPTaS could not simply be transferred to primary teachers. Only through using these interpretive and 'lived experience' approaches have I been more able to reconstruct PaSCuPTaS into aSCuPTaS to accommodate the effects a greater emphasis on science might bring to primary teachers and perhaps remove some of the barriers they feel when teaching science.

Max van Manen (1990) describes these research approaches as being rooted in the everyday 'lived experience' of human beings in educational situations. They have allowed me to develop greater understanding of my everyday 'lived experience' of change, of primary students moving into secondary schools and of the 'good' primary teachers can bring to science education. This understanding gave me ways to identify why I am supportive of the inclusion of science as part of the primary experience, why I stress the value of generalist primary teachers assuming responsibility for science teaching and learning, but most of all, this understanding opened my eyes to the role perceptive pedagogical practice can play to support the introduction of change.

To work in a hermeneutic and phenomenological way has required reframing my thinking from a methodology once more familiar to one that would come to resonate with me and one I would see as most appropriate for my research. It comes not from the positivist approach of the natural sciences but from the area of interpretivism or hermeneutics, or, as described by Arwen Raddon (2010), researcher as scientist versus researcher as detective. It is a human science research methodology commonly used when humans are involved, especially when their reactions and how they feel in different circumstances contribute to an inquiry—it is research that searches for possible answers to a wide range of phenomena that occur in health, education and social services. But it is not without measure—without measure it is open to criticism (Gadamer, 1975/2004).

As a science teacher, I am imbued in the scientific method of inquiry with its precise ways of ensuring the reliability and validity of quantitative data can be maximised—a method focussed on objectivity that leaves little space for diversion from set procedures. Despite this background, I have become increasingly aware of occasions when the nature of an inquiry does not fit the constraints of a scientific method. My inquiry cannot accommodate controlling all variables except that under investigation to do so might be inappropriate or not ethical. It is not viable to use large sample sizes, repetition, longitudinal studies or to remain unswayed by human feeling, impervious to tension. Collecting large volumes of quantitative data for objective study in a realistic time frame is difficult, it might delay acting on the outcomes of research and may ignore relevant information. I doubt the objective nature of a traditional scientific inquiry could have brought me to the same place of understanding I have arrived at through my collection and interpretation of qualitative data—only through this approach have I become able to understand more fully the fundamental, emotional effects change can bring to humans.

Human science methodology can take on many guises and may lead to many pathways. van Manen says,

> Heidegger talked about phenomenological reflection as following certain paths, "woodpaths" toward a "clearing" where something could be shown, revealed or clarified in its essential nature. However, the paths (method) cannot be fixed by signposts. (1990, p. 29)

I chose a path I sensed would allow me to focus on understanding my experiences with change as a secondary science teacher—what was it like to be a teacher in this time, why was I more readily able to adopt pedagogical and content changes in science than many of my colleagues, what did I see happening in my classroom because of these changes and how was the learning experience of my students changing? These observations between what was and what is became the measures of my inquiry—observable and felt, but not quantifiable.

It is a pathway that would contribute to my understanding of primary teachers and the impediments and barriers they may feel when teaching science—what was it like, what has it become? It has returned me to my personal interactions with primary teachers as a child, a student, a parent and a colleague. This pathway was to help me understand my intuitive response to change and my instinctive need to support the teaching of science in primary schools by writing a science curriculum for primary teachers and their students. It was a time when I believed I was taking a lonely journey but found it was a journey founded in the thoughts and ideas of many.

Hermeneutic reflection has helped me understand the relationship of trust that might be necessary between curriculum-writer, teacher and students if the written words of a curriculum are to speak to primary teachers in the way of "communal truth" described by Palmer (1983/93). van Manen (1990) considers phenomenology as the most appropriate method to explore phenomena of pedagogical significance. He draws from other philosophers, Martin Heidegger, Edmund Husserl, Gadamer, John Dewey and Levinas but focuses on the area of pedagogy. van Manen (1990, p. 2) describes pedagogy as, "the activity of teaching, parenting, educating or generally living with children, that requires constant practical acting in concrete situations and relations". I use this methodology to explore the pedagogical responsibility I have assumed in my curriculum-writing and have hoped to demonstrate through the written words of aSCuPTaS. aSCuPTaS is my voice—my way of 'speaking' to primary teachers when opportunities for physical dialogue are unavailable, but I must question the authenticity of the words I say and whether I speak with pedagogical tact (van Manen, 1995) when I place myself in the role of curriculum-maker.

As curriculum-writer, I have translated my understanding into a concrete form, in this case not artwork, poetry or literature but a curriculum. It is this concrete expression of the interpretations I make of my 'lived experiences' and those I understand belong to primary teachers that perhaps differentiates my inquiry from others. I have objectified the subjective experiences that are my 'lived experiences'—subjective experiences that have given me the tools, "to be as perceptive, insightful and discerning as [I] can be in order to show or disclose the object in its full richness and in its greatest depth" (van Manen, 1990, p. 20). aSCuPTaS may be the object of my inquiry, but it is an object to which I have given voice—a voice to which I have assigned responsibility to communicate and introduce opportunities for dialogue between curriculum-developer and teacher. Only through developing some deep understandings of change and of primary teachers have I been able to write a curriculum that is pedagogically sensitive in its way of teaching—explicit but gentle, encouraging not demanding, accessible not closed.

The authenticity of my text and interpretations of experiencing change came from being within in the throes of change—I trust them, although they might differ to some degree with those of others who have had similar experiences. But aSCuPTaS is also dependent on my knowing of primary teachers so I might speak with them in an authentic way. I have not been a primary teacher and have not lived through the years when science has become a more significant part of their curriculum. To understand how they find these experiences and how they feel about them is critical to the trust they might have in aSCuPTaS. I am conscious of this weak link in my inquiry—I look at the paths I have taken to give my understanding more authenticity in Chapter 2. I believe I gained sufficient authentic knowledge of the primary teachers themselves to be true to their needs when writing aSCuPTaS—to know what I might include, the language I might use and what might be best to leave to the discretion of individual teachers.

But, I would hesitate if I stood poised on the edge, aSCuPTaS in my hands, anticipating what might come from the mutual dialogue that might take place if I handed it to primary teachers without one further step. This step would take me to a further venture into qualitative research—a small study using the method described by Malcolm Parlett and David Hamilton (1972) as an illuminative evaluation. If the reaction of primary teachers is positive and the ebb and flow of dialogue between us begins, I will be satisfied in the interpretations I have made because in the past the dialogue between curriculum-maker and teachers has lapsed into silence, leaving some generalist primary teachers struggling as science takes a new precedence in Australian schools.

aSCuPTaS does not rely on interpretation alone—I have adopted the knowledge of others whom I came to trust when I was teaching. The practical support of the *Statements of Learning for Science* (MCEETYA, 2006) for the content of the curriculum, and the Teaching for Understanding website (www.pz.harvard.edu.projects), *The Teaching for Understanding Guide* (Blythe, 1997) and *Teaching for Understanding. Linking Research with Practice* (Wiske, 1998) have guided aSCuPTaS' format and depth of understanding. Before and during my inquiry I have also referred to two Australian documents which express the views of science educators about the future directions science teaching might take (Rennie & Goodrum, 2007; Tytler, 2007)—a future that has been and gone but still leaves many teachers struggling (Lowe & Appleton, 2015; Fitzgerald & Smith, 2016).

Despite the measures I have taken to ground my curriculum with the ideas of others and to search for its trustworthiness, it is not universally applicable. It may be momentarily fixed and appropriate for some primary teachers and their students in Australia at this particular time, and may be able to be massaged to meet the needs of primary teachers for some time in the future but its structure and function are not intended for longevity—time changes teachers, students, environments, needs and more. Perhaps some slivers of the understanding I have brought to this inquiry may linger a little longer.

As the curriculum-writer, I am accepting accountability for finding how and why any generic description of a curriculum might be altered to suit the needs of primary teachers. I see it as my responsibility to provide a pedagogically sensitive curriculum to primary teachers that will support them to teach science. Essentially, I need to make it available and accessible to primary teachers—to fill the 'gap' of which Goodrum (2006) speaks.

But, there is a little more. van Manen (1990) expresses the extra dimension so clearly.

> When I love a person (child or adult) I want to know what contributes to the good of that person. So the principle that guides my actions is a sense of the pedagogic Good; at the same time, I remain sensitive to the uniqueness of the person in this particular situation. (p. 6)

For too long, I sense we have recognised the individuality of students without considering the individuality of their teachers. Following van Manen, my focus is pedagogical and my intentionality is about empowering teachers to teach in the fullness of their humanity and agency.

In the same way as those using a natural science approach to inquiry might do, my methodology took me on a path to find the truth of my understanding and the truth or validity of the object I created, aSCuPTaS. Unlike the natural science approach there was no set path that would lead me to truth or not truth. Although I would collect data to support my ideas, I would not be able to say here are some universal principles and facts that can be applied in all situations, regardless of particular values (Raddon, 2010). My methodology would result in an object that began as an intuitive response to change but would become more substantiated because of the systematic and thorough inquiry I have undertaken to find its common ground with others contributing to this area of inquiry. But this grounding does not verify the purpose of aSCuPTaS alone—until we see that it communicates pedagogically with primary teachers when they teach science, that is, we see it talking with primary teachers until they understand that they do have capacity and can have confidence to speak with their students about science.

I have found some possible answers to the questions I ask in my inquiry. They have been determined by the experiences I describe in my writing but have grown and changed as my inquiry has crept forward to reveal more of its nature rather than being present in the beginning. Other questions continue to bubble to the surface as I write—for some I have possible answers, others dwell in my mind until another time.

MEMORANDUM — WHAT I TAKE WITH ME

Throughout my inquiry I determinedly keep in mind my strong focus on general primary teachers, the anxiety they might face when teaching science and the ways a curriculum designed for them might help eliminate at least some of these uncertainties. But I also remain conscious of the strengths and possibilities of primary teachers that need to be preserved and encouraged to strengthen their agency when teaching science.

When I accept the role of curriculum-developer, I must remember to maintain the strong sense of morality and responsibility towards the teachers who might use my curriculum and the students they teach. As I write I must remain conscious of my unwavering belief that an understanding of science is something that should grow during our life experience. To find science included in the primary school curriculum is a privilege that I would like to remain, at least for a time. Part of my responsibility is to find a way to help primary teachers enjoy giving their students opportunities to connect with science because they have such a privilege. Unless used, this privilege might be lost.

I bring my history to my inquiry—a history that includes my knowledge of science and science teaching, my experience of change and my growing understanding of pedagogy. I bring my disposition to questioning, dialogue and communication. All come in the package that is me, a product of my life experiences, genetic makeup and factors that may be less easily determined. I must be wary of settling for a subjective truth because there is no reality "out there". We too easily settle for a reality "in here", for a truth that consists of little more than our private perceptions and needs (Palmer, 1983/93, p. 54). I seek a truth that is not only my personal truth but one that is sensitive to the needs of others, a mutual truth. This search for mutual truth is an underlying current of my inquiry.

Whilst I feel rather presumptuous putting myself in the role of curriculum-writer for primary science, when I have limited teaching experience in primary schools or in curriculum-writing, it is my appreciation of primary science learning that drives me. I am not looking to bring science specialists into primary schools, I am picturing bringing a science curriculum to generalist primary teachers that helps them infuse an appreciation of science in their students in a loving, caring way, as in the role of a pedagogue—as part of their upbringing. But what becomes increasingly clear as my writing proceeds is that I have also approached writing the curriculum as a pedagogue, employing skills I learned as a teacher as traditions of education changed, particularly in science education. This approach encourages me to look for the individuality of teachers in the way teachers look at the individuality of their students. I am not looking to recreate primary teachers in my image but look to providing some boundaries, some guidelines that give them the freedom to work in ways they see fit for their students.

I have acknowledged my concerns about science teaching in primary schools. These concerns came from working with young students moving from primary to secondary school, from the writings of others about the teaching and learning of science and my growing understanding of primary teachers, particularly in Australia's primary schools. I hope my way of being explicit but gentle and encouraging rather than demanding might bring a sense of pedagogical thoughtfulness to aSCuPTaS that could overcome some of the apprehension primary teachers may have about science teaching.

NOTES FOR THE READER

Memorandum

At the end of each chapter of my inquiry I have added a memorandum, a reminder of what I have learned from writing each chapter and what I need to remember as my inquiry unfolds. It is the impression I am left with as I move to another group of thoughts—an impression that may shape or sway the way I proceed.

Art

Each chapter includes a small art piece at its beginning. These are symbolic of my hope that aSCuPTaS, with its guidelines and support materials, will give freedom and agency to primary teachers to produce unique science units suitable for them and their students.

Each art picture evolves from a small square of one of my original digitally created prints sourced from several photographs of the natural Tasmanian landscape. This small square I compare with aSCuPTaS, it is the common ground from which future creations grow—for me, the chapter motifs and for primary teachers, their science units. I hope each piece of mine echoes the possibilities for the science units I envisage primary teachers writing using aSCuPTaS—each one is different but evolves from the same source.

Names

Throughout my inquiry any first names I have used in my personal writing are imagined ones for the real students and teachers I have encountered and the school where I undertook an evaluation of aSCuPTaS.

For subject names I have not capitalised letters except for language names such as English and titles such as Biology Department.

E-materials

Some e-books do not have page numbers comparable to their print version. In my in-text citations I have given section titles for the source of the citation. Other e-materials, such as online newspapers and magazines have only their title as shown in my reference list and no page numbers—these have the date only in the text.

Hyperlinks

I have included hyperlinks within the document when it might be helpful to online readers.

CHAPTER TWO

SENSES OF DISQUIET

Towards the conclusion of my teaching years there were senses of disquiet emerging almost simultaneously about science education in Australian schools. One was happening in secondary schools, the other in primary schools—both were to do with change. In secondary schools this change related to the shifting views of science education, its content, purpose and the increasing role of an inclusive pedagogy attentive to the individuality of students. Concerns expressed at this time pointed to the slow uptake of these changes by secondary science teachers and the impact this might have on already diminishing numbers of students choosing science subjects beyond their compulsory inclusion (Rennie et al., 2001; Clark, 2003; Corrigan, 2006; Goodrum and Rennie, 2007; Osborne, 2006; Tytler, 2007). In this chapter I search for possible answers to the questions, why might teachers be reluctant to change their pedagogical approaches to teaching and why are students not continuing with science in post compulsory secondary years?

In primary schools the change related to a growing emphasis on a more planned teaching approach to science—this emphasis continues to grow now the *Australian Curriculum: Science* (ACARA, 2017) is fully implemented. The concerns have focussed on the reluctance of many primary teachers to embrace the inclusion of science (Appleton 1995, 2003, 2008; Dinham, 2007) and the inconsistency of science teaching in Australia's primary schools. My focus is on the question, what causes primary teachers' reluctance to teach science? Some believe they already have an answer—primary teachers have inadequate science knowledge. I am not so sure.

In my introductory chapter I speak of the secondary science teaching experiences that would trigger my writing of aSCuPTaS in its first form, PaSCuPTaS. In this chapter, I explore the possible sources and truth of my concerns for primary science teaching. I do this to help me develop a more authentic understanding of what it is like to be a primary teacher and how being a primary teacher differs from being a secondary teacher. Only by listening to the voices of primary teachers and questioning how they differ from those of secondary teachers would I be able to find possible answers to the question, how might a curriculum for teaching science in primary schools differ from one used by secondary teachers? Asking these questions might improve my practice as a curriculum-writer and would contribute to my living theory of curriculum-writing (Whitehead, 1985, 1989, 2008, 2009), which grew during my inquiry. Whilst the opportunity for me to be a primary teacher during a time of significant change had passed, without coming to know and understand the primary heart with more certainty and without examining the secondary heart that spawned aSCuPTaS, the product of my living theory of curriculum-writing, might be without a strong foundation.

To enter the primary heart, I have looked with a hermeneutic eye, an interpretive eye to make meaning of my personal encounters with primary teachers and phenomenological texts written by them in the context of teaching and science. At times I have added more traditional sources to enrich my interpretations, as I move closer to my primary audience and understand more deeply the needs they may have and the strengths they might contribute to the teaching of science in their schools. To enter my own heart, that from which PaSCuPTaS/aSCuPTaS flowed, I return to my experiences of change in a secondary setting and how my reactions differentiated me from many of my science colleagues.

I believed there might be considerable differences between these two groups of teachers and the purposes of science teaching in secondary and primary schools that might necessitate different focuses in their curriculum for science teaching.

AMONGST CHANGING TRADITIONS

I begin by writing about my reactions to changes in a secondary science setting. Biesta (2012, p. 38) writes "the point of education is never that students learn but that they learn something, for particular purposes and that they learn it from someone". In this section I explore how as a 'someone' I changed my views of the responsibilities I should take as a teacher and my understanding of the purpose of secondary science teaching.

Whilst an autobiographical narrative might seem indulgent, it is necessary to develop an appreciation of the background and traditions I brought to the writing of aSCuPTas. My interpretations of these experiences, of 'living amongst changing traditions', as a secondary teacher ultimately help me comprehend more deeply how and why I changed many of the traditions I brought to my teaching career and why I was willing to accept many of the changes suggested in my teaching life—changes many of my colleagues found more difficult. I begin with a story of change.

I began to talk of 'we'

I came to teaching from a science background—a 1972 graduate with a Bachelor of Science from the Australian National University and a scholarship for a Diploma of Education from the University of Tasmania—given with a promise—a Year 11/12 college position teaching biology, a prized position. This happened, for three days, I was moved on—insufficient numbers for another biology teacher in the college.

A new school—open plan, discovery learning—that was all! I survived the first year of nothing but discovery—the 'promise' remained but not for 1974, perhaps 1975?

My promised career began in 1975!

But, in my city the bridge ‘came down’, severely cutting communication between two sides of a large river. I began a year of travel. An hour to the ferry, no parking, a 45-minute queue if you were lucky and a ten-minute walk—the return journey in the afternoon. Not so bad. I enjoyed my teaching using the familiar BSCS textbook—used in my last year at school. Few facts remain with me from that course, it was more like an intelligence test, but it wakened an interest in science I had not found before. An interesting and relatively uncomplicated course to teach, its content clearly described—negligible preparation or marking—a laboratory technician to organise practical lessons—two short reports, two term exams and one state one at the end of the year. But the travelling and family crises tipped the balance. I moved to a school nearer where I lived—a different experience.

On my first day, it was like this. A syllabus passed to my hand from that of a snowy haired man in a white ‘lab’ coat—typed and copied in rather faint and unreadable ink on a spirit duplicator, and a small, rather tattered textbook with a faded green cover. I went to my laboratory, for this was where you ‘did science’—five benches, three-legged stools and an elevated plinth where I waited, also wearing a white ‘lab’ coat almost to the ground, for my pupils. They filed in, sat down and appeared before me, perhaps 30 faces—not dissimilar to my school days. It wasn’t so bad, I had a syllabus and a ‘faded green textbook’—I knew exactly what I must do.

End of an era—I stopped full-time teaching to tend to my family of three. I still went to the school of the ‘faded green textbook’ as a ‘support’ teacher for a few hours each week—whatever it was I supported, I don’t remember.

1981—time to leave the alternative life of the country hills—two goats, two dogs, many cats and a cow. Time to become more responsible. From 1981 until I finished teaching I found myself in the secondary section of a K-12 independent girls' school—Year 7 to Year 12, with an emphasis on Year 11/12 biology teaching. A textbook and syllabus—still nothing much different than it had been when I was at school from the mid 1950s until 1968, mostly rather dull like the 'faded green textbook', but peaceful.

Until the late 1980s.

New trends in education. My school was a little on the tardy side in the beginning but our growth was fuelled when ideas and workshops began to flow from the State Education Department and began to be discussed. This slow trickle of ideas soon became a raging torrent. Towards the end of the 90s, I had become so captivated by what was happening, I changed my focus from teaching Year 11/12 biology to working mostly with Year 7 and 8 students. I was smitten by what I was seeing but overwhelmed by the volume of materials and the inexhaustible words, even though an experienced science teacher. I struggled—terminology, strategies, different views—current best practice—21st Century science classrooms—21st Century teachers. Teaching was 'moving forward'—co-operative learning, learning styles, assessment, catering for the individual, self-esteem. Ideas quite foreign.

Conflict was not uncommon.

Conflict over suitable spaces for teaching in this new way—moving between laboratories and classrooms for each of the four lessons a week I had with my classes was unworkable. Continuity was interrupted, there was no place for work to be displayed or work in progress kept—students were producing 'things', display was important. Laboratories came with immovable benches—inflexible for communions of students in small groups, for circular, inclusive class discussion rather than one where the class lined up in front of me, still balanced on tall, three-legged stools wearing 'lab' coats. These conditions didn't fit my needs!

It was a time when I began to talk of 'we'—how I had come to think of the relationship I had with my class.

Conflict continued—over assessment. Assessment for me changed to formative assessment, but only behind closed doors—summative assessment remained as the one that 'mattered' for reporting to parents. Complexity developed, I often found myself in a 'great mess' trying to balance assessment in a way that was 'good' for students' learning but also truthful to parents.

Conflict over classroom time. Classrooms cluttered by the continuing and increasing needs for testing, to meet deadlines, to keep records —for reporting—often incompatible with my new ways to teach and my students to learn. Ways that called for dwelling in a space for learning, not a cursory glance, remember, test and move on to the next topic before there had been a chance to understand. I often lost track of time, the original purpose of lessons forgotten—we diverted from planned ideas to discuss 'more important issues' that arose—quite often.

Conflict over preparation time. There were new ideas to be considered. Thoughtful decisions took time. Decision-making in 'school time' was almost impossible given the nature of teachers' daily routines and increasingly encroached on personal lives. There were questions to be asked before I could claim which of the many and varied suggestions might be 'right' for my students. I drew on my experiences teaching science, my personal background in science and tried to be objective in my decision-making, but often there were no objective answers to find if I took my cue from science—my answers came from intuition, from faith and belief. Many strategies were unmanageable—unwieldy in nature that called for reworking to be made more manageable. Many had assumed a purpose of entertainment—needed to be reconnected to science or perhaps abandoned. Each step needed time.

Conflict over science content. At first I had little interest in making significant content changes. I soon perceived a need and made some hesitant suggestions about such things. Conflict came from my science colleagues, who mostly leaned towards traditional science—factual knowledge, replication of experiments to demonstrate principles and regurgitation of other people's ideas. I understood that changing the content of science might open science to a wider audience. I spoke the word 'inclusive' but often couldn't find the right words to say much more. Making changes was often quite lonely, exclusive—few voices of support came from my colleagues, especially those focussed on the senior science years, these voices often had a strong influence on the early science years.

After being introduced to Teaching for Understanding (www.pz.harvard.edu.projects) I began to write my own 'curriculum'—revised the content of Year 7 and 8 science units, placed greater emphasis on generic skills, widened my definition of science content, identified what I considered significant science. I had to be careful this would not disadvantage my students. Summative assessment and reporting became the limiting factors to how much I could change in the culture of my school environment. When I shared some of my planning with colleagues from throughout the school, I was asked, where is the science? My curriculum focussed almost exclusively on pedagogy and included little science content—this was what came readily to me—another question, why didn't you become a primary teacher?

For the last 10 years of my teaching I adopted a more structured and analytical approach when assessing the impact of the different ways of teaching I was initiating. I was using action research described by McNiff (1988/92) in a casual way. I say 'casual' and, at the time might have said 'unreliable', because I was not collecting data of the sort I was used to in science—data that was quantitative, could be represented by tables and graphs and easily analysed so conclusions could be drawn. My conclusions came from observation and interpretation—watching, listening and interacting with my students and then identifying the changes that were 'good' for them and for me. I don't say 'casual' anymore.

I stumbled over barriers, made mistakes, experienced conflict and spent hours on decision-making and planning during the time I have described but it was perhaps the most interesting time in my teaching career. What I saw and heard in my classroom and the discussions about pedagogical practice, generic skills and assessment that were taking place were sufficient incentive for me to accept that change was needed. But often I found myself longing for more support—a 'faded green textbook'—and more time to concentrate on my students.

Trying as these experiences were, I worked around them and overcame some of my earlier difficulties. Management became important to me—teaching had become an act of juggling not experienced in the peaceful times of the first half of my teaching career. Little management, other than at the level of behaviour management, was needed in those early years, especially in the school of discovery learning.

My classroom was more interesting. I found activities to engage students and provide authentic contexts my students could connect to more easily. I changed the balance of assessment to one emphasising formative rather than summative assessment—a chance to keep a closer eye on my students' learning about science.

My teaching was more rewarding. I enjoyed seeing students who had trouble with more traditional approaches to learning beginning to blossom, I saw students learning from each other as they shared ideas through dialogue, writing and art and I came to understand my students more than I had ever *done before—I let myself know my students and I let them know me, a little bit. I was enjoying my teaching although sometimes frustrated.*

But there were bigger questions that added to the discussion and confusion of this era. They were the significant philosophical discussions about the purposes of science learning in schools, who should have the opportunity to learn science, why students should be learning science, what science ought to be learned and is science learning best approached from a disciplinary or integrated base? These are the questions and possible answers that often got lost in the bedlam of these years of change—when few were left time or silence to think beyond the moment. There were sufficient moments of silence for me to develop rudimentary answers—they developed into the principles that I speak of in Chapter 3 and that came to underpin aSCuPTaS.

ESCAPE FROM SOMETHING THAT DECEIVED

This long story of change that threads through more than thirty years of my teaching brings some answers to my question about how I reacted to changing traditions. Now I look more closely at why I reacted in this way when many of my colleagues did not. Usually I talk of 'colleagues' in a general sense but in my narrative writing I use 'colleagues' to refer to the people in my school.

My previous narrative is a tale of what it was like amongst shifting sands for more than half of my teaching years, a journey that took me from a secure, relatively peaceful and predictable time to one of more discord, dispute and friction. But it was also a time for me that was more exciting and challenging and gave me greater satisfaction and sense of worth in my chosen career as my responsibilities grew—if only the disharmony could be calmed. This story has much influence on my inquiry because it is about the changing nature of secondary teaching, particularly science teaching.

It is a story of many things—space and place, peace and conflict, lost opportunities and hope, abandonment and wandering, acceptance and inclusion, openness and blinkered retreat. It is a story of the 'good' and 'bad' of being in the middle of a changing world—at its centre I found challenges to my fundamental beliefs of the purpose and values of science teaching in secondary schools and questions of why, in company with others, I was more easily tempted to rethink the traditions of a science education I had grown up with and adopt significant change—viewing them with hope rather than the inflexibility of retreat shown by some of my colleagues.

To teach had become something much more than to lecture. I have used the word 'lecture' to describe the narrow view of teaching I experienced as a secondary student and in my early teaching career, a space filled with words from one mouth, not the open space of which Palmer (1983/93, pp. 71-72, 77-79) speaks —space that becomes possible even in some lecturing. Teaching became something of greater responsibility for me in this time—responsibility that included giving students opportunities to grow and give shape to their lives "by learning what is worthwhile knowing and becoming" (van Manen, 1990, p. 158). To teach became an opportunity for me to watch my students grow into the skin of their individuality, not to recreate themselves in the image of the teacher (van Manen, 1990, p. 159). These are words that spoke of 'letting go', of abandoning some traditions that had driven science teaching when I was a student and in my early days of teaching—the deceptive days of teaching I felt robbed me of making full use of the opportunities that were possible as both a student and a teacher—if only I had known.

For me, and some of my secondary colleagues, to change to a more encompassing concept of teaching and to 'let go' of that traditionally accepted one that focussed around the idea of lecture, may have been difficult if these ideas had not captured our interest. Pedagogical change would not have deserved our interest "if it did not have something in it to teach us that we could not know by ourselves" (Gadamer, 1975/2004 p. xxxii). It would not have attracted me if it did not have something I could connect with and understand. What I was being offered in these new ways of educating might have helped me "escape from something that had deceived [me] and held [me] captive" (Gadamer, 1975/2004, p.350). I felt deceived by what was often acknowledged to be the only way of teaching since secondary education became available to more people until late last century. The exclusive pedagogy of that time may not only have deceived me as a student but many students I taught in my early career. I speak more of my feeling of deception in Chapter 3.

I was ready to accept change when I began to hear this ‘new’ pedagogic story because I could understand the positive effects it might have had on my education. I could see how it might support many of my students and could see the satisfaction it would bring to me as a teacher, because to work in this way was to make my teaching role more interesting and give me more responsibility. But many secondary science teachers appear to have found little in it to arouse their interest—it was foreign and irrelevant for them. The mere notion of learning about science was sufficiently encouraging, even in the passive way of reading, listening, watching and repeating—an intrinsic motivation to know and understand more about science.

Many of my science colleagues as students, needed no invitation or bribe to help them learn about science and perhaps translated their own enthusiasm into that of their students. This deception, resulting in exclusion, was significant in the way science was taught. Palmer writes,

> The teacher may love the subject in a possessive way that prevents the students from entering in. The teacher may be so protective of the subject, and of his or her relation to it, that students are required to accept the subject on the teacher’s own terms, discouraged or forbidden from assessing the subject and finding their own relation to it. (1983/93, pp. 104-105)

Or, perhaps my colleagues believed science as the domain of the gifted, or at least moderately so. This may be an ungracious thought, but Tytler hints of something similar. He describes some science teachers’ resistance to change as the

> silent choice of teachers for the status quo; one which supports and reflects their identities as knowledgeable experts. Science teachers tend to teach as they themselves were taught in school and through university, supported by assessment practices which confer status on the ability to manipulate canonical science ideas, and very little else. (2007, p. 57)

So, this resistance to change by secondary science teachers may not only be due to a lack of understanding for the need for pedagogical change but may come from a feeling, perhaps even a slight fear that pedagogical change would challenge or threaten their love of science or want to take it away (Palmer, 1983/93. p. 105). But clinging to these ideas would cause significant problems in the retention of students in their senior school years.

Secondary students' lack of engagement with science in Australia's schools has been recognised and has generated significant response, so much so that in 2006 the Australian College of Educational Research held a conference titled *Boosting Science Learning: What will it take?* (https://www.acer.edu.au/eppc/past-conferences) with a strong emphasis on engagement. Tytler (2007) wrote a comprehensive review, *Re-imagining Science Education: Engaging students in science for Australia's future*. Concern about this problem continues and in 2016 there was another conference, *Improving STEM learning. What will it take?* (https://www.acer.edu.au/eppc/past-conferences) featuring concerns about the low number of students taking STEM (science, technology, engineering and mathematics) subjects. Perhaps, there will be more change. I wonder at the value of isolating ideas such as STEM and STEAM, STEM plus the arts (Nicholas, 2016; Smith & Nutchey, 2016). My belief is these ideas of cross-curricular inputs into school science need to be integral from the early years and can be if science is viewed holistically and more inclusively. These are ideas that return in future chapters.

My disposition made it relatively easy for me to come to understand the purpose of a more liberal interpretation of pedagogy and of science content that went beyond the canonical so that it appealed to more students. Many of my colleagues found changes in content and pedagogy difficult. I ask how I might describe what I believe it is to teach now, because it has changed with time and more experiences. The space I find myself occupying represents the fusion of many experiences—I am unable to place my melding of ideas neatly into any of the theories of learning or methods of teaching that evolved from the changing times I speak of because what I make of these experiences relies on my interpretations and I am unique, I am human. Some might say I moved from a teacher-centred to a child-centred pedagogy, sometimes interpreted as a constructivist or progressive approach but neither of these terms capture my vision of who I am as a pedagogue.

When I consider what it is ‘I do’ as a science teacher, I turn not to a neatly packaged term but to the generous words of van Manen (1990, p. 156) who speaks of pedagogic competence based on the elements of pedagogic thoughtfulness and tact. I like to think the personal responsibilities of teaching I grew to believe in are ones that reflect my growing pedagogical competence, they include the many decisions I might make in both the short and long terms to help my students become engaged in education with an emphasis on learning about science. I write ‘emphasis on science’, because my responsibilities as a pedagogue would encompass more than knowledge of science. What my words represent is the creeping expansion of the roots of my purpose of teaching science from one of teaching my subject to one of teaching my students about my subject and all the responsibilities this has come to entail. To me it represents a shift in my responsibility from one that focussed on teaching a knowledge and understanding of science to one of inviting students to come and learn and understand about science. It is a subtle difference and the point I make is that my sense of pedagogy and invitation has not diminished my appreciation of science. As John Dewey writes,

> I do not wish to close, without recording my firm belief that the fundamental issue is not of new versus old education nor of progressive against traditional education but a question of what anything (sic) whatever I do must be worthy of the name education. (1938, p. 40)

It is Dewey’s words of 1938 that helped me understand more why many of my colleagues were reluctant about changing their ways of teaching science and the content of science because of the ways these changes were communicated. To explain I return to Biesta’s statement “the point of education is never that students learn but that they learn something, for particular purposes and that they learn it from someone” (2012, p. 38). This resonates because of its focus on responsibility for what is to be learned and for what purpose it is to be learned.

Biesta (2015) writes that the word ‘learning’, as it is commonly used today in its intransitive form, is a lonely word until specifically linked to what is to be learned. I copy with the word ‘engaging’, another word commonly used in relation to education. In its intransitive form, ‘engaging’ is also a lonely word until specifically linked with what you are engaging—in this case science. Unless students are engaging with science, many will not have opportunities for learning about science—engagement without having anything to engage with might be an exercise in failure. And yet, the words ‘engaging’ and ‘learning’ dominated the era of change I speak of.

I return to my story *I began to talk of ‘we’* on my page 33 and the notion of expanding the pedagogy of science teaching and content of science that inevitably brought debate, often ending in unresolved conflict. The reaction I saw happening in the microcosm of my school environment was perhaps representative of the wider arena and some of it may have been caused by misunderstanding. In expressing my enthusiasm for change I may have misled my colleagues into believing I had forgotten about the subject of science. I believe there was perhaps something in the way I expressed my thoughts that might have deluded them into thinking my thoughts of ‘engaging’, a word without an object, implied the science was no longer there. It was not my intention to forget the science, I remain with a strong appreciation of science, but it is so easy to drown words with enthusiasm that they become lost. I do not believe this excuses the lack of interest for developing a more inclusive practice, rather it helps me in my role of curriculum-writer to remain attentive to the way ideas are communicated.

Similarly, ideas of changing the content of science seemed to become synonymous with diluting or diminishing science as a discipline. Communication may also have contributed to this misunderstanding. Its purpose was to make science more accessible to and inclusive of students by providing more familiar context—this idea may also have suffered from its purpose not being made explicit. On the surface this idea of making science more appealing through content change, appears to have become more accepted in Australia, and has been written into curricula since the mid-1990s. I call it ‘humanising science’, a way to see how science has been used in societies throughout history and the moral and ethical implications of this—a way of introducing opportunities for questions that go beyond the boundaries of traditional science. I return to my time as a Year 11 and 12 biology teacher to help my understanding of why these ideas often became challenging.

In senior classes there was always a driving sense of time, by introducing a more comprehensive content and taking time to engage students with these ideas potentially decreased the time available for students to understand the canonical science that prevailed when it was time for the final examinations. To lose time to humanising and engaging science and not having sufficient time for students to bring a good return when they sit their final examinations was a constant fear. The humanising science criterion was an internally assessed one in my time and generally became relegated to an assignment, perhaps two. David Jardine writes,

> Such matters become leftovers, extras. In the real world of schools and Provincial examinations and parents' demands for "accountability", getting to it "later" is not really an especially urgent manner [matter?] "in the real world" I now understood to *be* isolated, testable, controllable, predictable, and manageable fragments. After all, "first things first". (Seidel & Jardine, 2014, p. 68)

I understand this anxiety, but lost this driving sense of time in my latter years of teaching when I dwelled in the humanity of science with my Year 7 and 8 classes —perhaps those who took my place in the senior classes were forever 'catching up' time lost.

I found it hard to convince my colleagues of the 'good' a broader conception of science might bring. They remained unmoved by discussions of science literacy, connecting science to the experiences of their students or notions of community science, particularly when the 'kitchen garden' seemed to become a focus for science in Australian schools—the merit of these ideas and the changing definitions of science literacy has been more thoroughly discussed by Peter Fensham (2004) and Leonie Rennie (2006). I found much of this discussion interesting and many ideas found a place in my classroom, but this was only a small part of the broader conceptions I was developing in my classroom practice that took me even further away from many of my colleagues.

I had taken science in my Year 7 and 8 classes to a slightly different place, one I hoped would be more encompassing of the individuality of my students. It was strongly influenced by Howard Gardner's book *Frames of Mind: The Theory of Multiple Intelligences* (1983/1993). I did not translate his ideas into learning styles, which Gardner has criticised (2011) but as a way of giving my students more options to communicate their understanding of science with me, their peers or the class. It was a way of taking science beyond the narrow traditions of science writing as the only way of communicating science understanding. In very simple terms I expanded my pedagogical practice by changing the emphasis in science from its logical-mathematical bias to include opportunities for linguistic intelligence and each of the remaining five areas Gardner (1983/93) originally identified—musical, bodily-kinesthetic, spatial, inter-personal and intra-personal. A whole new area of pedagogical choice unfurled for me. I talk much more about this in Chapter 3. My ideas often fell on unreceptive ears, including those in upper secondary classes but also those in lower classes and from disciplines beyond science.

Perhaps, if I could have explained my purpose in using Gardner's multiple intelligences more eloquently at the time, I might have had greater success in swaying the thinking of my colleagues. More recently, stimulated by Gardner's book *Five Minds for the Future* (2005/2009), I began to see my motive in using multiple intelligences was more than one of communicating science, it was my way inviting 'different' students into the circle of science, of adding value to the collective knowledge of those within the science area and the possibilities this might bring to the future of science.

Gardner describes his five minds.

> With these "minds", as I refer to them, a person will be well equipped to deal with what is expected, as well as what can't be anticipated; without these minds, a person will be at the mercy of forces he or she can't understand, let alone control. (2005/2009, p. 2)

I summarise his five minds as I have come to understand how I used them in my teaching. His disciplined mind I think of as a specialised one—it is the mind of students who have an interest, capacity and expertise in area of such as science. It is the basic idea behind Australia's inclusion of the strand *Science as knowledge* in its national curriculum—the science knowledge which drove many of my students and my early teaching life. But, Gardner (2005/2009) introduced other minds, notably the synthesising mind which has the capacity to bring together ideas from a wide range of sources. I like to think of this mind as the one that can visualise science in a holistic way, a mind the sees the 'bigger picture'. I found the words of these two minds helped me understand what I was trying to achieve as I taught science but Gardner's other three minds had also crept into my teaching. His creating mind brought opportunities to bring new ideas to science not only ones that might answer questions about science but ones that found new ways to communicate about science. Gardner's respectful mind brought opportunities for my students to demonstrate their respect and appreciation for differences amongst human beings and the ethical mind introduced ideas about responsibility as a student and as a citizen. Broadening the content of science could, I believe, only add to its worth by attracting these minds rather than focussing only on students with a science mind. A more encompassing view of science might have helped prevent the physicists from unlocking the science that brought Hiroshima to its fate and brought the scientists who enabled this to know sin (Palmer, 1983/93 pp. 1-2).

My initial purpose for changing science content focussed on ways to encourage students to connect with science as it is in their lives and help them understand the purpose of learning concepts of science. My purpose became more encompassing. It became one that encouraged more students to participate in science because of contributions and fresh thinking they might bring through strengths not commonly seen in science. Tytler (2007, p. 57) adds, learning about the "ability to manipulate canonical science ideas, and very little else" sets science in isolation and brings neither hope nor opportunities to the future of science. I believe this added dimension to science went beyond that of science literacy, community science and engagement—one that might have been more persuasive in encouraging my colleagues to think in a different way about the purpose of science teaching.

I found value in changing my pedagogic competence and where possible the content of science because of the possibilities of 'good' that accompany it, but 'good' is not easily measured except by watching for its effects in practice, by comparing what it was like before and after (Gadamer, 1975/2004). What I saw made me want to stay in my new place. I am not critical of colleagues or students I taught who survived and thrived with the science education I found deceived me, many would become scholars, educators and researchers at the top of their field—my concern remains with those who received no invitation and missed opportunities to extend their understanding and enjoyment of science. As I finish writing in this section I begin to realise my lack of words in this era had resulted in poor communication between me and my colleagues and between those who introduced the ideas that I attached to quite readily when others felt unswayed by their words. But I also connect this understanding to aSCuPTaS and how necessary it is when introducing change that words become meaningful and the purposes of the change become clear.

Secondary science education remains a concern in Australia but I leave it to others to pursue how these concerns might be addressed. My narratives and their interpretations that come from a human science research approach might bring different perspectives that add to the comprehensive notions Tytler described (2007). My writing highlights the significant resistance many secondary science teachers exhibit towards changing their practice and the traditions that underpin their views about the purpose of science. It is a problem I believe might bring harmful consequences to students and the future of science despite the best efforts of many.

I am not sure the problems faced by many secondary science teachers could be addressed through a curriculum written specifically for them. The difficulties that appear in secondary science education might come from a wider range of sources than in primary schools and perhaps revolve around who is invited into secondary science teacher education programs—those who have the knowledge, those who have the pedagogy or both. As Tytler (2007, p. 58) writes, it may have to come from pre-service courses that can bring "a breaking of the cycle of commitment to a canon of abstract knowledge delivered largely by transmissive pedagogies, and all that implies for individual teacher identity". But until a common understanding of the purpose becomes understood by all parties whom might contribute to the problem, there may be few opportunities for success.

Although I empathise with teachers and students in this secondary area of science, I turn with hope to primary teachers. But, of course, the nature of science teachers and teaching in secondary schools that I hint at appears exaggerated by my emphasis on those who remain resistant as this helps make my interpretations clearer. This emphasis hides the 'good' that is found in pockets everywhere as secondary science teachers weave their own magic. They are those who, "have done beautiful work that calls out, over and over, *we are here, we are here*" (Seidel & Jardine, 2014, p. 1), but might go unheard because to bring attention in this way is often not the nature of those who create these spaces.

From this section of writing, I take with me some strong notions that are relevant to my role as curriculum-writer, particularly ones that relate to purpose, communication, explication and invitation.

KINDLING THE LIGHT OF SCIENCE

My experiences as a secondary teacher made me more aware of the need for thoughtful and explicit communication as I embarked on my role as curriculum-maker. Before I could be thoughtful and explicit I needed to explore possible answers to a number of questions. The answers I found often evolved from my writing in *The Birth* (my page 2) and *I began to talk of 'we'* (my page 33), but my questions come from my role as curriculum-writer rather than teacher. What do I believe is the purpose of introducing science into primary schools? What was my purpose in writing aSCuPTaS in the way I did? How might the language of a science curriculum for primary teachers express these truthfully? How might a curriculum such as aSCuPTaS help primary teachers understand their role in and the purpose of giving aSCuPTaS life? I am in fact speaking of many purposes, the truth and trust that circulate around these and the questions of how these purposes might be achieved.

My vision of primary science teaching is that it has quite a different purpose from secondary science teaching particularly at the upper secondary levels. This introduces questions about how the purpose of teaching science changes throughout the continuum of Australia's science compulsory science years from Foundation(F), the year before Year 1 in primary schools when most children turn six, and Year 10. The last two years, Years 11 and 12, do not have compulsory science although this happens in some schools. My writing in this inquiry focusses on F-6, although, my mind is pulled towards a slightly different purpose in Years 5-8 with the developing ideas about middle school years.

My writing in this section begins with words from Biesta, who expresses something of my focus on 'purpose' with insight and understanding.

> The question of purpose is in my view the most central and most fundamental educational question since it is only when we have a sense of what it is we want to achieve through our educational efforts — and 'achieve' needs to be understood in a

> broad sense, not in terms of total control — that it becomes possible to make meaningful decisions about the 'what' and the 'how' of our educational efforts, that is decisions about contents and processes. (2012, p. 38)

I continue, with words that initially focus on my role as curriculum-writer by asking how my experiences with change in secondary schools might have been made easier for me and the influence they have had on aSCuPTaS. My final years of science teaching were less guided than when I began, there was an openness that created uncertainty and constant decisions to be made—so different from my early days as a teacher in a country high school when the beginning of a teaching year was marked by my receipt of a one-page syllabus, a 'faded green textbook' and an expectation to transfer this information to the students before me. This had become the accepted known of those times, shared in good faith and certainty of its truth.

I would not like to return to the 1970s because I found less 'good' in what was offered except for its simplicity, explicit guidance and the less frenetic life of teaching. As I moved into a more enlightened time of teaching, it was not about the content of science I was uncertain, my focus was almost entirely on extending my pedagogical competence so that I could take more responsibility for the choices I made in my classroom in a way that supported my students to learn about science. But, I lost faith in the truth of much of what I heard about pedagogy because it was often not simple, there was little explicit guidance and to sort these ideas increased the frenetic pace of my teaching life.

> [My] trust had slumped like old and stagnant moat water, thick, scummy, without current, then suddenly jolting [me] awake before sunrise with dreams of drowning in murk… Who or what is behind this lurking feeling that something is about to go horribly wrong? (Seidel & Jardine, 2014, p. 57)

It took several years before I realised I must search for this trust myself because it was not going to be handed to me. This took precious time I should have been spending with my students and talking with them, listening to them, attending to them and learning with them—being present not distracted by the decisions to be made, to find the right and wrong of the words from the known of the time.

When I look back on my writing I understand my use of the term 'bittersweet' on my page 4—for my changing world was one of pleasure with touches of sadness. The 'bitter' came from the difficulties I had and are revealed in the words and phrases I have used to describe my feelings in *I began to talk of 'we'* (my page 33)—struggled, overwhelmed, confused, uncertain, troubled, conflict and perhaps a word repeated more than any other, time. The 'sweet'—the other words that speak of hope, reward, engaging, managing, blossoming, opportunities and possibilities. These are words I associate with my emerging pedagogic competence and with my transformation as a teacher.

These experiences opened my eyes and caused me to rethink some of my long-standing assumptions of the purpose of learning science in secondary schools—who should be learning it and the changing role of science teaching. I found value in my rethinking as I watched the effects it was having on my students and the greater satisfaction I received from my teaching—these values might have positive consequences for the present and future of science and for those who teach and those who learn. But my writing has enabled me to identify four conditions that might have helped me to transform the traditions about science teaching and learning I brought with me at the start of my career more easily—the need for trust, time, purpose and guidance.

Teaching Transformed

I want to understand
What you ask for and why
I want to change and accept
Responsibility
For the classes I teach about
Science.

I understand it is my role, my responsibility
To become pedagogically competent
To invite my students into the folds
Of science.

But I need to know
The purpose of what your words say

The trust I can place in your words
And the 'good' they bring
To my students—to me.

I don't want your words
To tire me or bring me to tears
I want manageable words
I need time to change my perception
Of what it means
To teach science.

My narrative calls out for some resolution to the question of how much responsibility teachers might be expected to take for decision-making or even have the appropriate understanding to make these decisions. Biesta, Mark Priestley and Sarah Robinson (2015, p. 624) introduce the idea of teacher agency, raising the notion of how much responsibility teachers can realistically take for their work and the effects their individual beliefs might have on the overall quality of education. As I made my way through a minefield of change I felt I had too much responsibility and insufficient time to make all the decisions that might affect the educational future of my students. Biesta et al. write,

> While the research suggests that beliefs play an important role in teachers' work, an apparent mismatch between teachers' individual beliefs and values and wider institutional discourses and cultures, and a relative lack of a clear and robust professional vision of the purposes of education indicate that the promotion of teacher agency does not just rely on the beliefs that individual teachers bring to their practice, but also requires collective development and consideration. (2015, p. 624)

I translate Biesta's ideas into questions. When should teachers determine how, what and why they teach their students and when should the collective thoughts of those in higher authority take responsibility because the individual beliefs of teachers may result in actions inappropriate for students? It is a difficult situation, which I talk about in later chapters—questioning responsibility, purpose and mutual faith between teachers and authorities.

From these reflections, I started to wonder about the role I had accepted responsibility for in writing a science curriculum for primary teachers. I was beginning to think that in the Australian context many of the interpreters of what was becoming known about teaching might not have had time to digest and understand the ideas generated towards the end of the 20th Century, before being placed in positions of making choices and communicating these effectively as they developed curricula. This could explain why, often in the name of 'freedom' or 'for the 'good' of the students, much translation was left in the hands of teachers—what the translators did not seem to understand was how much time this would take and whether teachers have the capacity to do this. It was not 'good' for teachers or their students and the bond of trust had perhaps been broken. I explore these ideas in my next two chapters.

At this point yet another idea is emerging from my writing about the conflict in the way we, the teachers, received messages about pedagogical changes we were expected to make in the classroom. I had grown to understand that the messages I was receiving as a secondary teacher were about acting with pedagogical competence including sensitivity and tact towards my students. van Manen (1995, pp. 7-8) says, "the notion of pedagogical tact implies that qualities or virtues are the learned, internalized, situated, and evoked pedagogical practices that are necessary for the human vocation of bringing up and educating children". This was what I came to understand I was aiming for as I took the journey I have described—I am not sure I was always given these messages with the same sense of tact and sensitivity. My hope in aSCuPTaS is that it speaks more sympathetically to my intended audience about purpose and content and some elements of pedagogy and takes note of the four words of 'trust', 'time', 'purpose' and 'guidance'. These words represent my secondary calls, which is why I ask primary teachers to take me into their heart and let me know them.

PRIMARY TEACHERS TAKE ME INTO THEIR HEART

To speak sympathetically with my primary audience, I searched for ways that might take me into their heart—to feel as they might, as they experience significant changes to their teaching both generally and through the increasing focus on science. I remain conscious that I have not experienced these changes as a primary teacher but I ask, what might it feel like to be a primary teacher in this period of change? My focus at this stage is on general perceptions not science related ones.

The first stories I bring to this chapter come from my interactions with primary teachers as a child of teachers, and a student, parent and colleague of many teachers. These personal narratives of teachers transcend almost my whole lifetime and bring many different perspectives, particularly those as a student and a parent. I write over this longer period of time, partially because I have this opportunity but also because I believe some notions of a child-centred pedagogy have been part of primary teachers' practice from long before the words began to be whispered with tact into the ears of secondary teachers. Later in this section, I add the writing of two teachers, personally unknown to me, whose writing adds insight to my own observations, before I write my collective thoughts of how classroom life has changed for primary teachers.

Student — United Kingdom — 1955 to 1960

My first four teachers are well remembered
Women—each different bringing
Shared feelings of
Warmth, security—arms to hold you
Like a mother—when needed
But not mothers
Three were spinsters of the war.

Idyllic—this early school, my first
Learning—blocks and counting—sums
Writing stories—reading books
A chapter book from the blue bookcase (on wheels)
A milestone in those early years.

Did I learn to read and write—I have no memory
It happened—perhaps the teacher knew?
Year 4—some change
Desks lined up and groups
If you needed groups
B and A arithmetic if you didn't.

Follow the examples—they will show you
Finished—move on don't stop
No problem.

And practice—fill the pages
Write stories of witches and cats and cauldron spells
Read books, more books—I'm busy now
Some need my help
I'll read you a book—when I finish
A reward—more Bambi please.

And the other—the sometimes
History—tell us about when Alfred burned the cakes
Or about the bees in winter—let's grow bulbs—science
And don't forget Aesop's Fables—ethics
Some Bible stories?

One of the teachers plays the piano
Let's sing—the piano is not perfect
But nor are we
Another paints—we make pictures
I make a boat of balsa wood
And paint it green
A felt cat with yellow eyes
And don't forget the Christmas concert
And the sports day at 'The Club'.

There's a photograph, twenty-two of us
Yvonne has a birthmark on her face
Johnny wears the same clothes every day
Pauline has holes in her jumper
Eric wears glasses with wires around his ears
George has calipers—from polio.

We know who we are

That's Robert—left hand column—front row
Left hand seat—top of the class
Johnny—right hand column—back row—right hand seat

Same clothes every day—bottom of the class
Poor Johnny—it's sad
We played together—happily—usually
What happened to Johnny?

I almost forgot—a report
Once each year—a comment
For the first three years
Making good progress—and then
Excellent—very good—average
Must try harder
It wasn't much—enough.

Australia — 1960 to 1962

Nine years old—Australia—new school
Arithmetic—same book—same page
Tomorrow—next page—no further
Reading—same book—stand up
Read aloud—sit down—next one.

STAND UP says my teacher
The dusting's not done
The roster you know
What roster—what dusting?
I remember a ruler
It hits my legs—once—twice
I am new
I come from England
I cry.

I remember the weekly test.
The principal in front
Hands on heads—eggs five pence each
How many for three shillings and nine pence?
Hands on heads—pens down.

Dictation, essay, history, geography
Sturt—who is Sturt?

I come from England
I cry—again.

Craft—sew—a knitting bag
Knit—a baby's vest
A baby's vest—how do you knit?

I cried a lot—no warm arms
No welcoming words
No understanding this teacher
This school in Australia
Please—let me go
Back to England.

Another year—another school
In Australia.
The warmth returns
Well—perhaps a lukewarmth
Back to normal—almost
I stay now—I teach
In Australia.

Australia — 1984 to 1992

Three children—two schools
Independent—state.

A pattern—a regular pattern
Mornings—Literacy and numeracy
Afternoon—the rest
History—geography—music—art
Languages—Indonesian—sometimes French
Specialists—music—physical education.
Project work—worksheets plus
Anzac Day and the First Fleet.

Small groups
Teachers—female
Teachers marking

Student free time
Parents—asking questions
What can we do—what can you do
Mary has a problem.

Technology—television—tapes—videos
Tennis lesson—ballet lessons—music lessons
Gifted and talented programs
Sport—camps.

Teachers—busy—busy
Reports times three
Parent interviews times two
Changing times.

Australia — 2000 to 2016

2002—my daughter—a teacher
Trained in early childhood
Posted to Tasmania's West coast
Teaching—Year 6.

Tears
The cycle began.
Year 5/6, Year 3/4, Year 1
Kindergarten/preparatory
Isolated communities, small towns
Schools of 100—schools of 400
Tears.

Eventually
Preparatory/Year 1
A small school—110 students
8 staff members—close to home
A more permanent position
A class for whom she is trained
No travelling two or more hours each day.

Reports—deadlines

National testing—deadlines
International testing—deadlines
PUBLIC RANKINGS!

Meetings—parents, students, colleagues
Curriculum change
Professional development
Mixed classes
Behavioural problems
Special needs children.

Tears
No time to think
It is 2016.

And so, I move from my days in a small county primary school, where my father was the head teacher, to the tears of my daughter and many of her cohort. I write no further words of explanation except to say that whilst the words of my writing do not say the past was perfect they suggest there may be something amiss in the present.

I CAN'T DO IT ANYMORE

To my written memories of primary teachers and primary schooling I add writing from Gabrielle Stroud from Australia and Jackie Seidel from Canada and comments available from Australian primary teachers. Where possible, I have quoted words said by teachers—it is these words I want to burrow into, to get to the heart of and understand the underlying feelings that have led to public utterance of what it has been like to be in primary schools over a long period of change.

My memories release images of what remains in my brain—memories often extreme and emotive, good and bad, exaggerated in their remembering, forgetful of the 'bits' that fall between. I believe my memories represent truth but remain mindful of what Ross Poole writes,

> Memory involves a claim to truth, and it will not serve its other functions if that claim fails. But it is, as we are aware, all too fallible: it needs confirmation from, and is sometimes corrected by, other sources of information about the past. Our memory is always hostage to the facts of biography (if that is not too grand a term for most of us). Because we often fail to remember, or distort what we do remember, it is important that there be other ways in which the identity of our present and past selves can be established. Memory is not a self-sufficient ground of identity. (2008, p. 156)

By using my reflections in combination with other sources I hope to develop a more truthful picture of what it is to be a primary teacher by not becoming lost in concepts of primary teachers as an amorphous 'they' determined by the ways they have come to be portrayed. Karen Meyer says with some warning words from Heidegger.

> Normative expectations and ways we imagine our existence are always already carried in our narratives and images and limit possibilities, arguably to the lowest common denominator. In *Being and Time* (1962), Heidegger reminded us, lest we forget, that falling into the "they" in an undifferentiated way or inauthentic manner has the character of being lost. (as cited in Meyer, 2010, p. 85)

Specifically, I look at the changes primary teachers have experienced over my lifetime, but also what might have remained the same—I do this to help me understand the audience I want to use aSCuPTaS. The data I add to complete my picture has come from a report on the staffing of Australia's schools (McKenzie, Weldon, Rowley, Murphy, & McMillan, 2013) and a comprehensive, but somewhat out-dated report from 2007, about teachers in Australia's primary schools (Angus et al., 2007). There has not been such a comprehensive report since. This is possibly because of the focus on the development of the *Australian Curriculum*, which began in 2007/2008.

I believe Max Angus, Harriet Olney and John Ainley (2007), bring a more communal truth to the picture I have built of primary teachers and perhaps add a sense of being that, "usually misses itself and covers itself up" (Heidegger, 1962, as cited in Meyer, 2008, p. 2) as we live—information I may have missed in my recollections as a student, parent, colleague and friend to many primary teachers. To add ideas of what it means to be a primary teacher from the stories of my 'lived experience' alone might result in a biased interpretation where there is, "One truth for you, another for me, and never mind the difference" (Palmer, 1983/93, p. 55). It is the added communal truth from Angus et al. that has brought me to understand more deeply what it is to be a primary teacher without being one.

There has been little change to the female dominated nature of primary schooling in Australia with a ratio of approximately 4:1 female to male teachers. The average age of these teachers is in the early forties and they continue to be generalists, having studied many disciplines in their training so that in most cases they are expected to teach many subjects to their students (McKenzie et al., 2013), especially core subjects. Media reports indicate primary teachers continue to express concerns about the crowded curriculum (Medlin, 2010; Knott, 2011; Australian Primary Principals Association [APPA], 2014) especially since the advent of the *Australian Curriculum*, (ACARA 2017) although some concessions have been made after the *Review of the Australian Curriculum* (Donnelly & Wiltshire, 2014), and indicate the presence of stress amongst primary teachers (Stroud, 2016; Margolis, 2016). I find the concerns about the overcrowded curriculum and the growing reports of stress significant to my inquiry, and interpret my phenomenological writing and the writing of others to find the sense of these concerns in relation to aSCuPTaS. I begin to weave these thoughts together as I continue to write.

My interactions with primary teachers leave me with little doubt there has been significant change in primary teachers' lives since my childhood days or even those of my children. Words like 'simplicity', 'predictability' and 'autonomy' seem to have lost much of their meaning in Australia's primary schools as students and teachers appear to have fallen into lives overcome by distractions. "It would be a mistake to picture the primary school day as a predictable and smooth-flowing experience in which every moment is spent in some form of academic pursuit" (Angus et al., 2007). It has become a time when future events often take precedence, leaving little time to dwell on previous or present events —little time to contemplate, little space to ponder—or tell, as Jardine says,

> Stories of dogs and cats and kings and queens and luxuriating in the migratory arcs of their telling … this experience of time now seems the wonderland. Countless teachers have told me this … they are always already late, no matter what they do, no matter how they try. (Seidel & Jardine, 2014, p. 65)

Jardine suggests this is an ontological delusion that has set in, something that has become the “real world” for many primary teachers but this “real world” of primary teachers cannot be ignored because this is how they see it to be.

As suggested, the changing world of primary teachers is likely the result of an expanding curriculum, increasing external demands, increasing accountability with more assessment and more reporting and more contact with parents. Angus et al. (2007) recognise these changes but indicate many teachers remain positive and satisfied with their teaching roles—“… a new reporting system to be implemented by June have (sic) put so much stress and pressure on that I feel blessed and lucky that my 28 students are an absolute joy to teach” (Angus et al., 2007, p. 57). I am heartened by these positive words but at the same time concerned about the word ‘stress’ that begins to creep into this report and the negative effects it brings sometimes to primary teachers.

I am interested in the concept of stress as a possible response to change—changes that may have led Stroud to leave ‘The teaching life’ (2016), her story in the Griffith Review from which I take some excerpts.

> A knock at the door.
> The assistant principal. ‘I need your assessment results. Canberra just rang asking why our data isn’t entered.’
> It was a desperate feeling. A realisation. I was trying to do the impossible. I was destined to fail.
> There was pain in my chest, my heart clenching and screaming *LET ME OUT*.
> A cold sweat shivered on my skin.
> This is it, I thought.
> This isn’t teaching.
> I’m not a teacher anymore.
> ‘YOU’VE RESISTED THE urge for too long’, my psychologist tells me. ‘Fight or flight is a powerful instinct. Cortisol has been dripping into your system with every stressful day.’
> She mimes the drops of cortisol with her hands.

> 'Your body doesn't know if stress comes from work or a tiger chasing you. It responds the same. It tells you to do something – your body wants you to react.'
> Resisting fight or flight.
> That's what teachers do.
> For two weeks I cannot get out of bed.
> I am numb.
> How did I get here?" (Stroud, 2016)

Angus et al. (2007) alerted us to the stress experienced by primary teachers earlier in this century and Stroud's (2016) words show the stressful nature of primary teaching continues. I ask how an Australian primary teacher might have got to this point. There are many possible factors. The widening of the primary curriculum was already becoming evident in the report of Angus et al., *In the Balance,* and a strong recommendation caught my attention, "If the expectations [of primary schools] expand and the scope is broadened then, other things being equal, more resources will be required. However, the converse is also likely to be true" (2007, p. 4).

I am not sure this expansion has been curtailed and stress appears to have grown with the implementation of the *Australian Curriculum* (ACARA, 2017) and perhaps comes without a corresponding growth in resources. Kathy Margolis, in a transcript from the Australian Broadcasting Commission news (Margolis, 2016), also identifies the crowded primary curriculum as a source of stress. An experienced primary teacher, Margolis could not continue to teach in a system she did not believe—a system that resulted in her stress. Margolis says, "Never have I experienced a time in my profession where teachers are this stressed and in real fear for the mental health of not only themselves, but the children that they teach" (2016).

In their recommendations to the Review Committee for the *Australian Curriculum* in 2014, the Australian Primary Principals Association suggested the crowded curriculum has resulted from, "subject-based writers and advisers in each area engaged in – whether intentionally or unintentionally – a claim for territory" (APPA, 2014). Perhaps, because of an absence of any real understanding of primary teachers' lives, little attention is paid to how such demands can be met in primary schools. Consequently teachers are frequently left juggling time to accommodate changes whilst maintaining high standards in their literacy and numeracy programs, particularly since 2008 when the National Assessment Plan Literacy and Numeracy (https://www.nap.edu.au) became a mandatory inclusion in both primary and secondary schools.

Assessment, internal and external, national or sometimes international, has increased in primary schools adding to the workloads of primary teachers and setting deadlines to be met. Teachers provide evidence of grades for reports, spend time testing and assessing work using standards frameworks and work collaboratively with other teachers on their decision-making. Anecdotal evidence indicates many teachers find collecting evidence for report writing both challenging and demanding on time. Most write student reports, at least twice a year often with A-E ratings as advised in the *Australian Curriculum* (ACARA, 2017), as well as responding to parents both informally, as parents drop their children into school and formally, through parent-teacher interview. Stroud expresses her views,

> Mandatory.
> Standards.
> Imposed.
> There's something sinister happening to this profession that I loved.
> And it breaks my heart.
> And it burnt me out.
> We don't trust our teachers anymore. (2016)

But whilst Stroud expresses the fact that primary teachers are losing their autonomy for school-based assessment, they are taking greater responsibility for their students' social as well as intellectual development. Teacher number 60 says in the report, *In the Balance: The future of Australia's primary schools*,

> In my final year of teaching I've noticed the increased workload and accountability of teachers. Managing the behaviour of students is much more difficult and there are more poorly behaved students and lots of children on medication. There is less enjoyment in teaching and much more stress. Paper work has increased dramatically (e.g. risk assessments, documentation of poor behaviour) and schools are doing more

> of what parents and the community used to do. (Angus et al., 2007, p. 54)

Social support increases as more children and their families struggle with demands of the 21st Century. This involves time beyond the classroom—time for parent interaction, student intervention and for writing reports or having discussions about students who have been referred to specialists. Social problems may lead to behavioural problems, which in turn have placed greater demands on teachers to prepare and execute behavioural management plans. Stroud speaks of her concerns for Selina.

> Selina keeps me up at night. She made a disclosure two weeks ago. I had to report it. I've had a meeting with someone from Family and Community Services every day this week. No wonder she is such an angry little five-year-old. I'm angry too. (2016)

The proportion of Australian primary school children with disabilities has more than doubled since 1995 with 21.7 per cent of children having either medically- or teacher-identified needs (Angus et al., 2007, p. xi). This is the result of the inclusion policies outlined in the report from Disability Standards for Education (DET, 2005). To ensure their students' intellectual and physical needs are catered for they require special programs, adjusted facilities and funding for support teachers. Funding is often difficult to source, leaving teachers to handle situations that may be unmanageable. Thus, the benefit that might come from welcoming students with intellectual or physical needs into our classrooms comes down to funding.

Teacher number 177 expresses her concerns,

> I feel I must take this opportunity to 'tell it like it is' even though I have personally experienced many positive outcomes from inclusion and acknowledge the right of all children and their parents to choose their place of education. Many of the special needs students impede the teaching and learning of other students as they demand a comparatively large part of a teacher's time and effort. This occurs during class time because they need a completely separate academic program. I have spent so much time creating learning experiences that are appropriate for one child out of 29 or 30. (Angus et al., 2007, p. 56)

And yet Seidel writes from Canada about the mutual benefits from opportunities for inclusion.

> With her back to me, I could see Marie's diaper above her twisted and not quite pulled up sweatpants.
>
> Sudden and unbidden tears prickled my eyes. This vulnerable and intimate moment. A ten-year-old's incontinence and 25 other ten-year-olds' acceptance of this as a possibility for being human. (Seidel & Jardine, 2014, p. 12)

But, it is not only the recognisable individuality of children that brings complexity to the life of primary teachers—to those we trust with our children. Angus et al. say,

> During school visits by researchers, there was considerable evidence that teachers were being expected to manage students' health problems. Staffroom notice boards showed photographs of students with allergies, diabetes, epilepsy and other conditions for which an immediate response might be lifesaving. (2007, p. 54)

And it is more than the health problems that may have been recognised in my primary school of the 1950s for which teachers became accountable, it is an ever-growing list of categories as Seidel writes,

> Tomorrow the children arrive. They arrive already labelled and categorized. English as a second language. Refugee. Autistic. Down Syndrome. Attention Deficit Disorder. Gifted. Behaviour problem. Grade 3. Grade 4. Normal. The children arrive to me as categories, even before I meet them or know their names. My body prickles with anxiety. I am not ready. (Seidel & Jardine, 2014, p. 173)

The increasing demands on primary teaching, apparent in my text and in the words of others, have transformed the 'job' of primary teaching to one that has perhaps detracted from the joy primary teachers have watching their children fall in love with learning (Stroud, 2016).

It is a kind of magic, a kind of loving, a kind of art.
It is teaching.

Just teaching.

Just what I do.

What I *did*.

Past tense."

For Stroud (2016) it has changed.

> And now I'm scared for all the children in primary schools across Australia, because I think more teachers – more good teachers – are going to leave and in doing so, our country's very foundations become decidedly shaky.
> Who will teach our children?
> I can't do it anymore.
> I CLEAN HOLIDAY apartments now but sometimes, while I'm smoothing fresh linen over the beds, I imagine a student called Australia. Who would teach her? How would she learn?"

Perhaps this is what primary teaching has become in many countries, perhaps the purpose of primary teaching has changed with "schools being squeezed by the pressures and processes of global forces, both economic and political" (Seidel & Jardine, 2014, p. 171). In *Experiments in a Curriculum for Miracles,* Seidel talks of not having time for contemplative practice,

> All morning I have been rushing and rushing. There was another organisational staff meeting at lunch, and I have a meeting after school with a parent. The teachers pass one another in the hall at top speed. We laugh about it in these public places, but in private we talk about how stressed and overwhelmed we feel, how we might burst into tears at any moment. (2014 pp. 176-177)

And no one dares to speak of what it is like being a primary teacher in this world of 2016 when things have changed.

Changed Lives

So, primary teachers' lives have changed

By 2016

Filled now with'stuff'—that might not resonate

Imposed, unmanageable, their role

Stressed

For what purpose?

And yet, watch carefully
Because you might see them
Gently move towards the child
Whose parents split last week
Whose beloved dog died last night
Whose legs need help to move
Who might have just arrived—from England
Vietnam, India, Ethiopia, Cambodia
Burma, Afghanistan …

And listen carefully now
You'll hear them say
What's wrong possum?
Here, hold my hand—and I'll hold yours
Be careful now—I check the guidelines
A hand hug now—no mother's arms
Unless you are 'very young'
Distressed or hurt.

I must leave you now
To hand in my reports
With A B C—for scrutiny—you know
We don't trust our teachers anymore.

Whilst primary teachers' lives may have changed, I believe there are many who retain the caring, nurturing nature of those who brought warmth to my primary days. I believe they are perhaps 'a treasure' to be preserved, to be cherished and cultivated—these primary teachers to whom I entrust the teaching of primary science. It is these teachers I glimpse in myself in my recollection, *I began to talk of 'we'* on my page 33. I must continue to look closely at aSCuPTaS—to make sure these teachers can trust that what I have written for them brings energy to their teaching of science, not suffering.

SCIENCE AT THE WHIM OF THE TEACHER

For science to be more than something that appears now and again at the whim of the teacher fits comfortably with my vision for science in primary schools. I begin with a short narrative, one that focusses on the changing nature of science education in primary schools and runs in parallel with the general picture I have painted in the previous section—it emerges from my life as a student, parent and colleague of primary teachers.

A drifting place of science

United Kingdom — 1955 to 1960

At first it wasn't no science
Just science at the whim of the teacher
When bluebells came
Or kittens birthed
When nests had eggs—birds grouped on wires
Waiting—gathering flying.
I watched with my dad
He wrote a story
For a magazine—I saw it.

Thin slithers of the moon—that grew
Stars too far away—to imagine
Memories blurred—home or school
Of Jenner and Pasteur and Stephenson
Of scientists—what they do and what they bring
Of collecting shells and leaves and snails' homes
After they had left
Beginnings of wonder that might last.

Australia — 1961 to 1962

For me—no science to remember

Australia — 1984 to 2016

My children leave dull memories
Of science

Skeletons—naming—memorising
Plants—naming—memorising
Projects—quolls—planets—clouds
Writing—books—internet
Something new—another way
For information only.

I forget—just one who pressed flowers
Watched mould grow
On bread left behind—after lunch
And red dye light the white petals
Of a rose
Just one child
Just one teacher.

Today—call in the experts
Build science laboratories
Buy microscopes
Wear white coats and goggles.

Science
At the whim of politicians
Secondary science teachers—not me
The drive of economics
This is secondary science
We know that doesn't work
For most.

STEM—STEAM
Science is STEAM
STEAM is Science
If you make it so
Think again—please
Let's not throw the baby out.

We have some wonderful primary teachers.
Let's trust them with science
Let them trust us.

My writing returns me to the horizons of Gadamer,

> Thus it is constantly necessary to guard against overhastily assimilating the past to our own expectations of meaning. Only then can we listen to tradition in a way that permits it to make its own meaning heard. (1975/2004, p. 304)

My remembered view of science teaching in primary schools brings tastes of 'good' and 'bad' but I write it to remind us of Gadamer's words. I begin to see primary science education today could be swept to a place where there has not always been a beautiful blending of horizons of the past and the future that could open new and different vistas that might bring primary science to a breath-taking place of its own. We must not forget what primary science might be in the present if fragments of the traditions that came before have been preserved. I translate this particularly to the need for there to be flexibility in primary science, opportunities when science comes from the moment at the whim of the teacher as it might have done in the past.

In *A drifting place of science*, the wonder of the 1950s gradually becomes lost to the information of the 1980s and now this might all get lost to a secondary science model, a model we continue to try and fix because it has failed us. This is a model we often see pictured as lab coats and goggles—the place where I started. And maybe this forgetfulness has left us in some doubt of what we are trying to achieve by including science in the primary curriculum. In Chapter 1, I speak of my purpose for writing a science curriculum for primary teachers—in this section I explore my purpose of teaching science in primary schools.

My own experiences of science in primary school left me with few conceptual understandings of science, but gave me a compelling connection to the world around me that has remained with me. These powerful impressions have perhaps translated into my strong belief of how much science there is to be learned without the need for specialised equipment, teachers and facilities because there is science all around us—a rich source to be tapped—and not only science of a conceptual nature, science of wonder that comes from much wider sources and the interdependence of the lived and non-living world. Seidel adds a sense of wonder at the depths of the layers below and the infinite beyond.

> … feet dangling and dangerously quiet and alone but not really the night is loud and full and comes to meet us here we abandon ourselves to stars infinity strands us on this ancient shore laying on fossil layers of beach crushed sand we are swallowed and time bound where does it end and the prairie grass exhales sweet air caresses us good night. (Seidel & Jardine, 2014, p. 56)

It is this 'earthy', unpretentious science of touch and smell and sight that captures my imagination for primary science—a science I would like to see anew with my students if I was a primary teacher, because this is what it is to be with children, a chance to see again and wonder.

It is perhaps because of my strong connection to this 'earthy' science I worry about some of the changes I see in science teaching in primary schools. From the 1960s, science in Australian primary schools has changed—at one time it too was a flexible, 'up to the teacher' inclusion (Angus et al., 2007) probably much like my experience in the United Kingdom. Now, it is mandated and required with the implementation of the *Australian Curriculum* (ACARA, 2017). Primary science was changing from one that

> had a strong 'nature study' orientation: the life cycles of frogs, the growth of plants, changes in the weather. Primary schools explored the immediate world of children and sought to promote their curiosity, not to lay any foundation for the secondary curriculum. (Angus et al., 2007, p. 6)

I enjoyed these words of opportunity—a chance to explore the immediate world of children and to promote their curiosity. I enjoyed the words of content but I feel there is an implied sense that these opportunities to connect with the content of 'nature study' might become lost if primary science becomes one of laying the foundations for the secondary curriculum. Perhaps I am wrong in my interpretation, perhaps to lay foundations for the secondary curriculum does not exclude science as a chance to explore the immediate world of children and to promote their curiosity. Sometimes it is too easy to misunderstand words. As I trace the thoughts and memories of my inquiry I become more conscious of the need to be explicit about the purpose of teaching science in primary schools.

I appreciate science as an addition to the primary curriculum. I find it too important, too fascinating to be always left to the whim of the teacher. When I ask my purpose for teaching science in primary schools, I sense my notions might place me in a different space from some science-orientated educators. In the following section, I search for how the threads of primary and secondary voices may have become untangled.

UNTANGLING THE THREADS OF MANY VOICES

There are too many threads
Too many ideas
Too many purposes and beliefs
That become entangled
In the minds of those of us who
Teach science
Write curricula.

We must remember
At the heart of the web are
Primary teachers and their students
With different hearts and purposes.

To complete this chapter, I look more closely at why I pursued the notion of a science curriculum specifically for primary teachers as a possible way of untangling the threads of many voices—voices that spoke different languages, voices that spoke words easily misunderstood. Before I write the details of how more sense might be made of the voices that call, I write words that have become embedded in my mind because I heard them all.

I heard all the words

I heard all the voices
I heard what they said
My head changed the words

Of PaSCuPTaS/aSCuPTaS
So they were truthful to both
With minor diversions.

For secondary voices I might find a place for
Frequent reminders of pedagogy
And notions of talking of 'we'
If these voices would listen.

For the calls of primary voices
I slip in words of advice
About the science that may have
Escaped them when they were at school
These were words not too hard to acquire.

I think it is not too much to say
My listening, my knowing, my being
Is adding to my living theory
Of curriculum-writing
And the truth of aSCuPTaS
And the place of purpose.

I return to more traditional explanations of how these voices have become blended in aSCuPTaS because of who I am and the values that come from my experiences of teaching, the wider circle of my living and the opportunities these have given me to know and understand the two principal players who have influenced its writing. Often these players, secondary teachers and primary teachers, speak in different tongues—two voices that bring quite different perspectives to what it means to teach science. My writing of aSCuPTaS began because I could see the tension developing between these two groups as science in Australia' primary schools became more prominent—I found I could understand both.

I believe there are many primary teachers who have the potential to contribute positively to science teaching in Australia, they are the "wonderful teachers" Crook and Wilson (2015) speak of and the teachers who say words like, "I feel blessed and lucky that my 28 students are an absolute joy to teach" (Angus et al., 2007 p. 57), despite the stress and pressure of a new reporting system. But talk of wonderful primary teachers comes tinged with elements of sadness because of the disappointment many feel about teaching, not necessarily teaching science, just teaching. There are those who no longer contribute, like Stroud (2016) and Margolis (2016). And there are others who may not complete their teaching education, may not find a job teaching or may leave early in their career (Earp, 2016; McKinnon & Walker, 2016).

From outside the community of primary teachers in Australia concerns for science teaching have been growing over many years and there are those who 'know' how to overcome the problems—measured by the time primary teachers spend on science and students' results on international testing programs. Some question the lack of primary teachers' science competency (Appleton 1995, 2003, 2008; Dinham, 2007, 2014). This lack of competency has often been attributed to their generalist, usually non-science background—a recurring theme in the literature. Angus et al., quoting from a review of Science, Mathematics and Technology in Australian schools (2002) spoke of

> the uncertainty among primary teachers about how best to teach Science and the teachers' relatively low levels of interest and academic attainment in both Science and Mathematics. The report did not recommend increasing the time allotted to Science in the primary curriculum, recognising that, before this could happen, there would need to be a higher level of scientific competence among primary teachers and improved infrastructure for science teaching. (2007, p. 16)

The difficulty of interpreting curricula and the lack of support available in their schools have also been suggested as causes of the difficulties primary teachers have when teaching science (Rennie et al., 2001; Skilbeck & Connell, 2004; Dawson & Venville, 2006; Lowe & Appleton, 2015). This strikes a chord for me after the experiences I speak of in Chapter 1.

Primary teachers themselves allude to the crowded curriculum and the difficulty of finding space for science as one of the barriers to its teaching (Donnelly & Wiltshire, 2014, pp. 2-4.). This is not something new. "In 1982, the South Australian Education Department acknowledged that its schools were faced with a crowded curriculum and made recommendations about how to manage it" (Angus et al., 2007, p. 22). This trend continues and resulted in some changes to the *Australian Curriculum* (ACARA, 2017) in response to a review (Donnelly & Wiltshire, 2014) that aimed to reduce its overcrowding. This strikes a chord but I wonder if the crowded curriculum is perhaps not the whole truth and primary teachers may have been lured into a situation of fear in the way I had as a secondary teacher shown in my page 4—"a fear that has become far too apparent of late. Being lost in the sea of shifting impressions in our awkward age" (Mabille, 2012, p. 58).

Perhaps this feeling of being lost explains the positive reaction by those primary teachers who embraced *Primary Connections,* a science program introduced in Australia in 2005. Mark Hackling states, "the program improves teachers' confidence, self-efficacy and practice, students' learning, and the status of science within schools" (2006, p. 78). Perhaps *Primary Connections* is the 'faded green textbook' of my early teaching career that gave me confidence to 'stand and deliver' its words from the raised platform, my white coat trailing to my feet, to the blank faces of my students. Ken Appleton (2003) raises another point about fear,

> The teaching profession seems to attract people into primary teaching who fear science rather than love it … I would rather take the perspective that many of these teachers are achieving well within the constraints in which they have to work. (p. 21)

Appleton's words are generous to primary teachers—others are not quite so kind. I believe this fear may not only come from a lack of direction but from the notion of science being beyond the capacity of many in society, including primary teachers—this notion of science as 'exclusive'. I add that this fear might be associated with Australian primary students not gaining ground on international testing programs (Thomson et al., 2012, 2016) and the increasingly loud calls for specialised science teachers in primary schools (Dinham, 2007, 2014).

Numerous suggestions have been made to overcome some of the problems primary teachers experience when teaching science. Appleton (1995, 2003, 2008) has long focussed on teacher education as a way of supporting primary teachers to teach science—I agree. Appleton continues to express his concern. In conjunction with Beverly Lowe (Lowe & Appleton, 2015) they speak of their concern for teachers now embroiled in putting the *Australian Curriculum: Science* (ACARA, 2017) into practice. Rennie (2005, 2006 & 2007) focussed in her earlier work on supporting teachers, particularly primary teachers, to make use of opportunities offered in the local community when teaching science. These ideas have so much potential but never seem to happen for everyone.

Angela Fitzgerald and Kathy Smith emphasise the discord present in primary science and say, "the values and intentions of curriculum-developers do not align with the personal practical knowledge of [primary] teachers" (2016, p. 65) and the difficulty of achieving such alignment despite over forty years of research documenting this need. Stephen Dinham (2007, 2014) solves the problem by turning towards science specialists, which tends to shift the idea from support for generalist primary teachers when they teach science to replacement. Some state governments step in and fund this idea. Holly Bennett reports from Dinham in Melbourne University's magazine *Pursuit*,

> "A lot of people say the early years of high school should be more like primary school - I say the opposite is the case," said ACE [Australian College of Educators] president Stephen Dinham, chair of teacher education at the University of Melbourne. "If we're going to address poor maths and science results in high schools, we need to start in primary schools … Many primary teachers lack competence and confidence teaching maths and science". (Bennett, 2013)

I strongly disagree with these words. John Hattie (2009, pp. 50-51) has shown how important primary students' attitudes towards science are in predicting later achievement. I agree with the importance of good attitudes for predicting future science achievement but find it difficult to agree with what Dinham (2007, 2014) suggests when he appears to be saying these attitudes can only be achieved by bringing science specialists into primary schools. I believe generalist primary teachers have the potential and opportunity to develop these positive attitudes in their students if they are well supported to do this. I find Dinham's idea of specialist science teachers could lead to the purpose of primary school science teaching becoming more like that in secondary schools which is what he says he would like—something I am uncomfortable with because it leaves generalist teachers and their students without a space to dwell in science that begins with a "nature study orientation: the life cycles of frogs, the growth of plants, changes in the weather" (Angus et al., 2007, p. 6) and with less opportunities to develop a holistic view of science.

It is this struggle around primary science teaching, its purpose, values and who should teach it that I hope to untangle through yet another curriculum, aSCuPTaS, despite the difficulties of achieving alignment between curriculum-writer and primary teachers in over forty years of research documenting this need (Fitzgerald & Smith, 2016, p. 65). At the time I wrote aSCuPTaS, I found myself sitting in the middle—torn by beckoning voices. For my heart asked more primary teachers to find a space for science, when my writing reveals the suffering primary teachers already have because of external demands. Seidel writes there are,

> those who deny the mysteries and miracles of life by seeking to quantify and know all things, or by those who seek to control teachers' minds and words with this or that method, or those who want to separate children into winners and losers, more and less, champions and failures, strong and weak. (Seidel & Jardine, 2014, p. 8)

I ask primary teachers to teach science because of the value I place on the possibilities and hope their contributions to science education might bring. But I must be careful and wise and thoughtful of how I ask—forestalling further suffering that might be caused by the expressed beliefs of some secondary science teachers and academics. I am torn because I understand both points of view, that of primary teachers and secondary teachers. The narratives I have written emphasise my position of being 'caught in the middle'.

My explorations in this chapter help me understand more clearly my focus on returning responsibility for science teaching to generalist primary teachers through a curriculum designed specifically to attend to their needs when they teach science. Many Australian primary teachers see their prime academic purpose as supporting their children as they develop skills in literacy and numeracy (Donnelly & Wiltshire, 2014, p. 3). They are passionate about this and understandably want no time to be taken away. But most have another commonly held purpose, perhaps less palpable and less recognised. It is their strong sense of pedagogic responsibility and their competence to perform in this way that appeals to me. This responsibility for socialisation, which Biesta (2009) considers one of three essential elements in education, perhaps separates them from secondary teachers. It is a responsibility I glimpsed as I first began focussing my teaching on middle school students (Years 7 and 8)—once seen, it took hold of me and allowed me to become a little bit like a primary teacher. Like Stroud I began to feel that,

> Watching children learn is a beautiful and extraordinary experience. Their bodies transform, reflecting inner changes. Teeth fall out. Knees scab. Freckles multiply. Throughout the year they grow in endless ways and I can almost see their self-esteem rising, their confidence soaring, their small bodies now empowered. Given wings. (2016)

For some of my secondary science colleagues, there may have been few such moments to watch closely the minutiae of their students, their energy being focussed on their purpose of teaching their subject (Palmer, 1983/93, pp. 104-105) —"history, science, maths, a language — often in a way for science teachers like the way they were taught" (Tytler, 2007).

Senior secondary science students and their teachers emphasise their purpose as preparation for university rather than on the development of the more encompassing purpose of science literacy (Goodrum et al., 2012). It is perhaps because of this passion for subject that senior secondary teachers want this preparation to begin in Years 7 and 8 and want more time for science. They protect their subject and are often suspicious of the demands of co-curricular activities such as outdoor education that impinge on 'their' time. This was my purpose once, many years ago as a Year 11/12 biology teacher and in the time of the 'faded green textbook', until I asked why and allowed my purpose to be reset closer to my heart and *I began to talk of 'we'* (my page 33). My purpose changed, particularly for Year 7 and 8 students, but also perhaps in Years 9 and 10. I worried about the 'secondary' purpose moving into primary schools when talk of science specialists began and ideas that primary schools should become like secondary schools are uttered (Bennett, 2013).

When I was teaching secondary science, my purpose became one of keeping the light of science burning in the hearts and minds of many students, by offering opportunities that promote the inclusivity of science. I believe it will be from these diverse minds Gardner (2009) speaks of in *Five Minds for the Future*, not only the mind of the traditionally 'gifted' science students, that science of the future springs—a robust science based on ethics, communication and a strong conception of the interactions of science in a world of bigger pictures. But as I provided these opportunities to Year 7-10 students I remained sensitive to the science to be learned and the nuances of the language of learning and that of education, the need for the verbs I used to remain in transitive connection to science in the way of Biesta (2010, 2012). It is a combination of these ideas that helped me to become more pedagogically inclusive, particularly when teaching Year 7 and 8 classes. I speak with more certainty of these early years of secondary schools than those in higher years—I hesitate to be so definitive of the later years because of the conflict of purpose I hold.

As my purpose for teaching science changed, I could see how different I was from many of my science colleagues and how these differences helped me reassess my thoughts about science teaching. These changes enabled me to be more flexible in my teaching practice and to bring ideas of communication, STEM and STEAM into my science teaching, and change my vision of how science could become more inclusive. It also enabled me to see the advantages generalist primary teachers could bring to science teaching because they are not so focussed on the subject of science—ideas that might have seemed anathema to some of my colleagues. I am also able to understand why the purposes of primary science teaching are perhaps being dragged into a model of secondary science teaching because of the need for 'success' and it concerned me. I could speak and understand the language of both sides.

As science has filtered into Australia's primary schools and become a required discipline, I could understand why more secondary science teachers became supportive of primary science education when previously they believed science teaching and learning began in Year 7—"Formal Science instruction by specialist teachers began only in the first year of secondary schooling" (Angus et al., 2007, p. 16). I soon began to see their support for the inclusion of science in primary schools might be because it could serve their purpose and passion for teaching the subject of science. I could understand their words would take some pressure off the science to be learned in secondary schools, because their curriculum has expanded too, so there is more content to cover from Years 7-12 (Donnelly & Wiltshire, 2014, p143).

Perhaps the purpose of primary science as one of laying "a foundation for the secondary curriculum" (Angus et al., 2007) has been translated literally and science teachers and others on curriculum committees have become acquisitive. In the *Review of the Australian Curriculum* (Donnelly & Wiltshire, 2014, p. 2), the reviewers write they have "heard substantial evidence that content was added to the curriculum to appease stakeholders, which has led to an overcrowded curriculum". Now more science content has been added to the primary curriculum, the stakeholders want to have more control of what takes place in primary schools, criticise those less 'able' to teach it and contribute to the call for specialist teachers. These ponderings are generalised but perhaps with elements of truth—ideas that make me suspicious of what drives our thoughts, although Seidel (Seidel & Jardine, 2014, p. 171) and Angus et al. (2007) make no secret of the economic and political power that influences education.

Hence the science curriculum in primary schools has grown and primary science and secondary science appear to come closer in purpose. Even in *Primary Connections* the purpose creeps towards preparing students for the future with one fact sheet expressing ideas that *Primary Connections* prepares children for the future by "equipping children for modern workplaces so they are able to consider further education and a career based on these subjects" (Australian Department of Education, n.d.)—these subjects are literacy and science. This model, with an emphasis on such a distant future, is not my vision for primary science teaching. My thoughts have drifted far from the time I assumed primary science contributed little to the important matter of science in secondary schools and I understand now that many primary teachers have much to contribute. There are stories that tell us this.

"When students move to high school, many experience disappointment, because the science they are taught is neither relevant nor engaging and does not connect with their interests and experiences" and "Traditional chalk-and-talk teaching, copying notes, and "cookbook" practical lessons offer little challenge or excitement to students" (Rennie et al., 2001, p. 486). These are words said in 2001 but are reiterated from the Office of Australia's Chief Scientist (2012, pp. 43-56).

There have been many discussions and conferences about how to reverse the decline in secondary students' interest in science including *Boosting Science Learning*, (2006) and *Improving STEM Learning* (2016). Australia's Chief Scientist in 2012, Ian Chubb, talks in *The Mann Lecture* (Office of the Chief Scientist, 2012) of engaging students,

> Students like the Australians who recently attended the biggest STEM competition in the world - the Formula One in Schools Challenge in Abu Dhabi. It's a team challenge that pits nine million students from 17,000 schools in 31 countries against each other in a competition to design, test and make miniature F1 cars. The Australians took out categories including the Fastest Car and Best Engineered Car, as well as the Best International Collaboration award. If you were writing the marketing campaign for science education to resemble the practice of science more than it currently does, you might say "Engaged Kids Do very well!"

I think many teachers recognise competition of this sort makes few offers of science education because it 'engages' only those lucky enough to have these opportunities and perhaps we need to place more emphasis on and be more explicit about what science students should be learning and engaging with and for what purpose (Biesta, 2010, 2012, 2015)

My own experiences and who I am have allowed me to develop some understanding about what might cause the misalignment of curriculum-writers and primary teachers when they teach science (Fitzgerald & Smith, 2016, p. 65). I believe this might be because the purpose of science teaching in primary and secondary schools has not been recognised and/or clearly differentiated. I believe this might leave primary teachers thinking teaching science in primary schools is like teaching science in secondary schools and this might contribute to their fear of science and loss of courage when teaching science.

Courage to teach science

To teach science in
Primary schools
You need a degree in science

Laboratories, equipment
More time for science each week
And then week after week.

You need smiling children
In goggles and white coats using
Flasks of brewing chemicals and
Magnificent microscopes
‘Take off your goggles please’.

You need lethal looking pipettes
Tongs and test tubes
Not plastic buckets
A hose—a stream
Or grandad’s old bicycle.

This is important stuff of science you know
Not cast offs and rubbish
Science will set you up for life
Help you find a job
And build the economy.

It lays the foundations for
Secondary science
If you make it to your senior years
It is exclusive you see
Only for a few
Who perhaps think the same way
As their teachers.

I apologise for this exaggerated view but it is not without some truth. My view is quite different—the opposite in fact—but it emphasises my concern about what science might become in primary schools. No wonder primary teachers might feel fearful about teaching science. I believe many of the perceived difficulties, sometimes almost superstitious in nature that primary teachers are experiencing with science teaching might stem from what they have come to see as the purpose of their teaching science and the way change has been implemented, often in an overt and negative way that might make primary teachers feel they are being pushed away from teaching science because of their inadequacy. I wish to explore ways of lowering the resistance they may have by examining how a curriculum designed specifically for primary teachers might remove at least some of the barriers of their resistance.

A CURRICULUM OF PRIMARY PURPOSE

In my search to 'know' primary teachers, I find the words 'primary teachers are not confident to teach science' used too frequently. I have a feeling the words should say, 'our lack of confidence in primary teachers is hampering their ability to teach science'—a notion strongly associated to that of 'self-efficacy' (Bandura, 1977). Once, when I was trying to introduce some pedagogical changes in the school where I was teaching, I was offended when asked why I did not become a primary teacher. Now, I am proud of teaching more like a primary teacher. Many years ago John Clark (2003) said, "Primary teachers obviously have strengths that need to be recognized and utilized when it comes to teaching science". It is these strengths I want to retain in primary science teaching. I believe keeping them needs the support of curriculum-writers who are able to talk to primary teachers in words they understand because science in primary schools has changed, but it has not become like secondary science.

Science teaching in Australian primary schools has changed significantly. In the 20th Century's early years, science found almost no place in Australia's primary curriculum, by the 1990s it had a small space, much less than the social sciences but since then there has continued to be a growing emphasis on science (Angus et al., 2007, pp. 15-17)—by 2014 all Australian primary schools are using the *Australian Curriculum: Science* for years F-10 (ACARA, 2017). Although how many actually use it directly is perhaps open to question as each of the States, Territories and individual schools continue to develop their own curriculum based on the *Australian Curriculum: Science*.

I have found many curricula written in ways faithful to what is known about science and science teaching in our times but question whether we are being as attentive to the teachers who use them as we might—if they are being written with the 'knowingness' of primary teachers I have endeavoured to pursue. I wonder if there is something primary teachers are saying and curriculum-writers not hearing or vice versa. Or, perhaps the 'knowingness' is available in the words of some during the collaborative discussions taking place around curriculum-development but gets diluted because to be inclusive everyone's view must be considered—in a short time because there is a deadline and something needs to be written.

I have come to know more about primary teachers from what I have written and know secondary teachers because that is 'me' and know what it is like to make change and know what I would like students coming from primary schools into my Year 7 classes to bring with them. I know why I have continued to pursue a different curriculum for primary teachers than one I would write for secondary teachers. All of this might sound like I am a 'know-all' but this is incorrect because my position in this inquiry 'has a foot in each camp'—as a secondary science teacher I support more regular science learning in primary schools but I am also empathetic to the resistance primary teachers are exhibiting as I have come to know them more.

At first I was unsure how to combine my ideas into *A Science Curriculum for Primary Teachers and Their Students,* so my feet came together in truth (Palmer, 1998/2007). aSCuPTaS is the product of my developing living theory of curriculum-writing, which Jack Whitehead describes as,

> … each individual's living educational theory (Whitehead, 1989) in improving practice and generating knowledge. It emphasizes the importance of individual creativity in contributing to improving practice and knowledge from within historical and cultural opportunities and constraints in the social contexts of the individual's life and work. (2008, p. 103)

At the time of writing aSCuPTaS, my theory was a scrambling of ideas in my head. It has become more grounded as I have written this inquiry and frequently asked the question, how have my experiences of teaching helped me improve my curriculum-writing? aSCuPTaS has grown from my own practice of teaching during a time when I constantly asked the question, "How do I improve my practice?" (Whitehead, 1989, p. 41). I do not bring video or picture evidence (Whitehead, 2008, 2009) but bring words and aSCuPTaS as my evidence. The pedagogical skills of my teaching practice gave me as sense of tact that helped me develop a sensitivity in my writing of aSCuPTaS that might have been absent if I had not had so many years of teaching experience that caused me to think.

This is the reason I have explored 'yet another curriculum', using a method perhaps less common in curriculum-writing—a human science method of hermeneutic phenomenology so primary teachers might become 'known' to me and me to them in the hope of finding why there might have been a breakdown in communication between science curriculum-writers and primary teachers that has resulted in a call for specialist science teachers in primary schools. There must be many school-based curricula that have been written by primary teachers with the sensitivity I hope comes with aSCuPTaS. I have been fortunate in having an opportunity to explore my ideas further than many.

Writing PaSCuPTaS, my first curriculum for primary teachers, was a risk for me as Year 7 and 8 teacher. It was "*The Beautiful Risk of Education*" (Biesta, 2013/2016) that worked for me in the lower years of secondary school. It was a curriculum clothed in pedagogical thought—one intent on making the writer, 'me', attend to my pedagogical actions moment by moment. I had become so hooked on this notion that I made it the central idea of the curriculum without understanding this was not what primary teachers needed. Their needs were unlike mine—they needed a different focus in a curriculum and I believe I understand now the changes I made to PaSCuPTaS to bring it closer to the primary heart.

PaSCuPTaS, emerging as aSCuPTaS, is my amended risk, it has become a curriculum of confidence-building with a strong purpose of increasing primary teachers' self-efficacy when teaching science—a curriculum I hope communicates to primary teachers with the same pedagogical thoughtfulness they speak to their students, one that engages primary teachers and shows my respect for the science opportunities they can bring to their children.

Fitzgerald and Smith pursue similar ideas about the perceptions primary teachers have about science and write,

> Providing alternative ways of thinking about science teaching may enable primary teachers to relinquish their personal feelings of inadequacy, build on their existing pedagogical strengths and provide a consistent science learning experience

> for all primary students. In this way primary teachers may come to see new possibilities and opportunities for science learning as well as realizing the potential science learning which exists in the experiences that they presently provide for their students. (2016, p. 75)

I have focussed on a science curriculum for primary teachers that might help bring this support and as well emphasise the positive effects primary teachers may bring because they are generalist teachers. As the Australian Primary Principals Association president, Norm Hart said, “specialisation had merit but would be difficult to implement” and he stressed that the need for personal relationship between teachers and pupils in their early years should also be maintained (Knott, 2015). My hope in aSCuPTaS is that it may alleviate some of the notions current primary teachers have about teaching science because they think it is beyond their capacity and may bring support to primary teachers to continue to be the principal purveyors of science education in their schools. I stress ‘current’ because I believe that even if there is a continued push for at least one science specialist in each of Australia’s primary schools this could take many years. Of course aSCuPTaS is not a new curriculum for Australia’s primary schools, it is only my dream, but it is a dream of what could happen right now to give primary teachers a chance to take responsibility for teaching science.

The purpose of the science they might teach is important. I believe to teach science in primary schools is to kindle the light of science to burn in the hearts and minds of primary students. To do this, students are invited to engage with science in a holistic way by exploring their immediate world, promoting their curiosity, encouraging a deep understanding of some introductory science principles, developing an appreciation of how science is used by humans and beginning to understand the limitations of science. By inserting holistic vision, I hope to present a view of science that goes beyond the concept of what I have come to call a ‘lab coat and goggles’ view of science, seen on almost every piece of documentation available for science education in Australia.

The purpose of aSCuPTaS is to help primary teachers achieve this. I had struggled with the methods of change—confusing language, poor communication, lack of direction and empathy, and no ‘faded green textbook’.

But it was the lack of mutual trust between those who take responsibility for making the changes and those who were dictating the changes—between teachers and the 'change merchants', the curriculum-writers, which had begun to strike a chord. I believe this lack of trust and understanding of what it is to be a primary, or in my case a secondary teacher, has become too common. This lack of trust in teachers and the demands for change that are made, are perhaps a common factor I share with primary teachers—it motivated me to write aSCuPTaS. The idea of mutual trust that must exist between curriculum-writer and the teachers who use the curriculum becomes central to my inquiry. My perception of the presence of primary teachers as invited guests to be respected and bring promises of new conversation (Gadamer, 1976/77) have encouraged my persistence to find expression in a primary science curriculum for our blended ideas of what it means to teach science.

There seems to have been some reticence about clearly expressing the purpose of education in the *Review of the Australian Curriculum* (Donnelly & Wiltshire, 2014 pp. 18-24) because of the difficulties it presents. In the *Australian Curriculum: Science* (ACARA, 2017) there is no apparent differentiation between the purpose of primary and secondary science education—purpose has been incorporated into the rationale for and aims of learning science. I believe the purposes of primary and secondary science are different, need to be explicitly stated and require differences in curricula structure. Biesta (2009, p. 11) suggests that, "in our discussions about the purpose of education we need to distinguish between the ways in which education can contribute to qualification, to socialisation and to subjectification". Biesta (2009, p. 7) uses subjectification to express respect for the individuality of students. I believe these three notions may require a different balance in primary and secondary education and again need explicit expression. I introduce more discussion around these ideas in Chapter 3.

The purpose of my inquiry is to find possible ways to remove some of the barriers primary teachers may experience when teaching science. My possible answer is via a curriculum such as aSCuPTaS. aSCuPTaS evolved from my living theory of practice as a secondary science teacher and my developing understanding of what it is to be a curriculum-writer and how I might improve my practice of curriculum-writing through my practice (Whitehead, 1985, 1989, 2008, 2009). Part of my writing helps me transfer with more faith my learning as a secondary teacher to a primary situation, because of my ongoing search as I write to find the truthfulness and trustworthiness of aSCuPTaS.

I say with more conviction now why I saw a need to write a science curriculum specifically for primary teachers. It is because primary teachers and secondary teachers have come to teach science from quite different histories that have led them to have different purposes and ways of teaching science. For many secondary teachers teaching science is by choice, although this is changing as science teachers become scarce in Australia. For primary teachers, their choice is to teach children, although this is also changing—science is an addition imposed from elsewhere and many come with few qualifications to take responsibility.

For now, I see aSCuPTaS as offering support to primary teachers because they do not have a strong science background and because I value science in primary schools. It has a strong emphasis on the ideas of science I want them to teach their children and is written in a way intended to transform their belief in their capacity to teach science, their self-efficacy. It has little emphasis on how they might do this because I trust their pedagogical competence to engage all their students in learning about science whilst retaining a holistic view of science by making connections to other disciplinary areas and it is a curriculum that heeds their concern that they work within a crowded curriculum. aSCuPTaS is different from a curriculum for primary science that many of my secondary science colleagues might write because I am different to them, an idea I have explored in this chapter. If I wrote a science curriculum for secondary teachers it would be different from aSCuPTaS, but retain some similarities.

MEMORANDUM — WHAT I TAKE WITH ME

Through writing this chapter I have come to understand more why, after forty years of endeavours, science education still poses challenges in Australia's primary schools (Fitzgerald & Smith, 2016). It is because there are many threads to disentangle—threads woven by secondary teachers, primary teachers, pre-school teachers, students, parents, academics and philosophers to name but a few. They become tangled by history, interpretation, supported beliefs, unsupported beliefs, terminology, communication, assumption and dictation. It is a mess awaiting disentanglement, but one I believe may be undone with the careful teasing of listening to and watching of those I write for—primary teachers and their students who each bring threads of their own, but threads that stay closely together and to the subject of science.

Biesta talks of giving teaching back to teachers.

> Perhaps there is only one thing I should say in conclusion, and that is that teachers should teach, that they should be allowed to teach, and that they should have—and perhaps regain—the courage to teach. (2012, p. 45)

My belief in my desire to give primary teachers the courage and opportunity to teach science to their students is central to my inquiry. Palmer also pursues this notion of courage when he writes,

> The courage to teach is also the courage to keep one's heart open in those very moments when the heart is asked to hold more than it is able to so that teacher and students and subject can be woven into the fabric of community that learning and living require. (Palmer, 1998/2007, Teaching Beyond Technique)

I believe the courage to teach may come with the return of the 'faded green textbook', but its return may be so well disguised in aSCuPTaS it is barely recognisable.

My writing in this chapter has often been personal, exposing difficulties and frustrations I experienced with change as a secondary teacher, acknowledging my strong desire for more guidance but recognising the need for change in the content, purpose and relationships of science teaching (Biesta, 2012) so that more students are invited to participate in science education. I leave my words of reflection with more understanding of why my acceptance of changes to secondary school science and its teaching were different from those of some of my colleagues. But it also helped me understand the 'difficulties of change' that might bring reluctance if the old traditions have worked for 'you' and your purposes. The 'you' being many secondary science teachers, who may not yet have come to understand the changing nature of science teaching.

I have expanded my horizons of what it is to be a primary teacher—to work within an already crowded curriculum, have pressures that come from the emphasis on literacy and numeracy, real or perceived, to take on increased responsibility for the social, physical and intellectual development of students with diverse backgrounds (Angus et al., 2007). I understand they may have little time for either the preparation or implementation of science learning, are not confident to teach science because they have had few opportunities to develop their personal background in science either in their senior secondary school days or in tertiary teacher training, and they work in a wide range of environments where the facilities available are varied and the composition of student populations and availability of collegial support are inconsistent.

But I understand too, that it is the responsibility of those of us who welcome science as having a greater role in primary schools to find ways that might remove the snags and hitches that might be present. I ask how my learning and my understanding of primary teachers has guided my writing of aSCuPTaS so the light of science might shine in the hearts of primary teachers who in turn might kindle the light of science to burn in the hearts and minds of their students. To see this "flow of life affirming energy" (Whitehead, 2008, 2009) will become my measure of the success of aSCuPTaS.

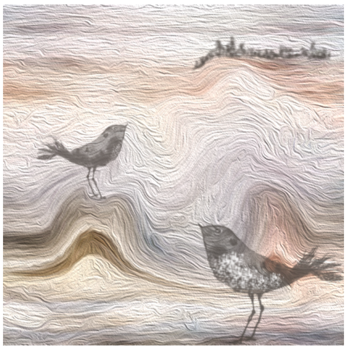
To kindle the light of science is a metaphor I have used throughout my inquiry. It is borrowed from Naoko Saito (2005), who writes,

> Dewey, after Emerson and Cavell, would argue today that the prophetic light, which can never be grasped through fixation, is to be watched in its transition, in the 'intermediate possibilities', that it offers. It requires another space, another language, and another vision of education—a turning of our ways of seeing education. Dewey follows Emerson in naming this the space for the 'education of the human soul'. (2005, p. 139)

I ask can aSCuPTaS bring the energy of Whitehead (2008, 2009) and the prophetic light of Saito (2005) to kindle the light of science to shine and educate the souls of primary teachers and their students?

I wonder if the light of my understanding will go anywhere towards achieving the goals expressed by Stroud (2016), "I think about students learning for the joy of it, not for the test of it—learning science because they love it, not because 'they perform well' in it". I hope so—I care about science learning in primary schools and trust primary teachers are the right people to support their students to travel this path. But, I hope aSCuPTaS might also bring opportunities for primary students to go beyond 'love' and also perform well as they learn about science in a gentle and perceptive way from their teachers. I hope there is nothing sinister in aSCuPTaS, it is too easy to lose teachers for reasons that could be avoided—I play the refrain again,

> There's something sinister happening to this profession that I loved.
> And it breaks my heart.
> And it burnt me out.
>
> We don't trust our teachers anymore. (Stroud, 2016)



CHAPTER 3

TO WHOM THE MANTRA CALLS

This chapter is the first of three where I continue my reflections on experiences I had as a secondary teacher during the long periods of change I speak of in Chapter 2. The overall purpose of these chapters is to bring an understanding of why a curriculum such as aSCuPTaS might contribute to the restoration of energy-flowing values that give meaning and purpose to those who teach science in primary schools (Whitehead, 2009)—each chapter brings a different focus. In this chapter, my purpose is to explore the concept of responsibility, particularly the distribution of responsibility between curriculum-maker and primary teachers and my belief that these principles are as relevant for primary teachers as they are for me.

To this exploration of responsibility, I add others that help me understand questions about purpose and what constitutes 'good' science education (Biesta, 2009; Biesta, 2012). I make these explorations because of my deep appreciation of the vocation of primary teaching, and the inclusion of science as part of the primary curriculum in Australia. My appreciation gives me energy to search for greater truth in aSCuPTaS—to know with more certainty that the principles, which represent my living theory of teaching science (Whitehead, 1989) in secondary schools and I use to underpin aSCuPTaS, could be transferred to a primary situation. I revisit them to ensure they bring a 'good' science education, not harm, primary students and the teachers who accompany them as they explore ideas of science in what might occur, otherwise imperceptibly, in their everyday lives. Seidel writes of what might be seen,

while walking
we [they] find leaf skeletons
and wonder at the way
the life of the leaf has
dissolved become
earth

we cannot find even evidence
of the leaf in the soil but
our hand's hold
this planet's breath

life structure fine bones so fragile remember
snows frost insect bite
sun   wind   rain   dark
falling light gives way to
gravity calling earth back to earth
(Seidel & Jardine, 2014, p.39)

It is this perceptible science, science that is all around for children to wonder at or imagine if they look closely, that bids me to gather it into a small gift for primary teachers, aSCuPTaS—a gift of hope—hope that it might encourage more primary teachers to feel comfortable and understand their purpose and responsibilities when teaching science. A gift that through its principles might bring children Seidel's (Seidel & Jardine, 2014, p. 39) sense of science and the wealth of pedagogical opportunities that are available to learn about science.

But my hope for science in primary schools has the potential for increasing tension between primary teachers and those who support its inclusion. This comes from my asking generalist primary teachers to take responsibility for science learning because of my belief they bring opportunities for 'good' that might be diminished if the growing call for science specialists is not considered carefully. I also recognise, that if I have not shown compassion for and understanding of primary teachers in writing aSCuPTaS, then it might also bring harm—harm already damaging primary teachers (see Chapter 2). van Manen asks "the pedagogical question. How are we to act and live with children, helping them to create their human capabilities, while realizing that we are apt to do damage?" (2012, p. 8).

When taking responsibility for the decision-making and evaluations in my own practice from which the principles evolved, I was acting in the role of curriculum-maker and teacher for my classes. In addition to exploring each principle, I look carefully at how the two roles I assumed might become shared between primary teachers and curriculum-maker to the benefit of both. It would become a balancing act of how our knowledge and understanding could be combined in the best interests of everyone—curriculum-maker, teachers and the children we value. I do this to bring greater credence to my belief that by sharing responsibility for practising these principles through aSCuPTaS, I could bring freedom to primary teachers and help eliminate some of the alienation, oppression and subordination they may feel when teaching science—feelings that might diminish their sense of self-efficacy and contribute to their reluctance to teach science. Many of the ideas I bring result from the constant self-dialogue that accompanied me as I took a journey that enlightened me of the conditions that might rob some members of society of opportunities—I talk of teachers and students—for possibilities of freedom, dignity, and hope (Biesta, 1998, 2012).

In Chapter 4 I have written more deeply about the evolution of some of the 'big ideas' of pedagogical practice that are inextricably bound to purpose, opportunity and the matter of science and how these elements and the principles of Chapter 3 might be articulated in the words of aSCuPTaS. The final chapter of this interconnected series, Chapter 5, is when I look at the trustworthiness of aSCuPTaS—a curriculum whose evolution relied on my interpretations as a secondary teacher. It takes aSCuPTaS beyond the theoretical and gives me an opportunity to see it through the eyes of those for whom it has been written, primary teachers.

Through my writing in these chapters I become more mindful that my role as curriculum-writer is one of pedagogy—not about how I act with children, but how I act with teachers to give them the courage and energy to teach science without hurt. I do this so together we can work in trust and harmony—in the same way I have faith primary teachers will act and work with their children. As I travel through these chapters I see more clearly the nuances and responsibilities that make my role of curriculum-maker intimately entangled with the roles of teachers and their students and the way they might contribute to our understanding of a web of education values through which energy flows (Whitehead, 2009). We become a close community with interdependent needs and offerings—none of us exist without the other in the same way as many beautiful 'families'.

Kittens' birth

I had no idea of where each one came
Slipping in wonderous sac
To rumpled newspaper lying on orange-red tiles
Of the 'Rayburn' warmed kitchen.

Another and another until there were six
Washed, welcomed and tucked away
Before the next
Appeared.

Mother cat had milk and meat
She purred and stretched
Proud at her delivery
Then fed her babies week on week
While we fed her
And she fed them
In those blissful weeks of watching
A beautiful community of trust.

But to take this journey without linking my principles more explicitly with what has grown to be my purpose in supporting the teaching of science in primary schools leaves the principles without foundation, stranded in a space without connection to what happens in primary classrooms. My purpose is stronger than the inclusion of science in the primary curriculum and evolves from my experiences in secondary schools—it is the sequel to my purpose of teaching science in secondary schools. Although I write it in my previous chapter, I include it again here. I believe to teach science in primary schools is to kindle the light of science to burn in the hearts and minds of primary students. To do this, students are invited to engage with science in a holistic way by exploring their immediate world, promoting their curiosity, encouraging a deep understanding of some introductory science principles, developing an appreciation of how science is used by humans and beginning to understand the limitations of science. By inserting holistic vision, I hope to present a view of science that goes beyond the concept of what I have come to call a 'lab coat and goggles' view of science.

I look in this chapter at each of the principles and how they intersect with my purpose for science teaching in primary schools and my purpose in writing aSCuPTaS to support primary teachers to teach science. I look carefully at who might take responsibility for each of the principles and how this will be done so together, as curriculum-maker and teachers we take responsibility for creating a science education in primary schools that could perhaps be, in the words of Seidel,

> an education that could bear mortality, an education more interested in the natural world, in relationships, in lower and deeper time. It is an education that does more in school: more interesting, more challenging, more human, more lively conversation and work. Yet without becoming more *busy*. (Seidel & Jardine, 2014, p. 149)

PRINCIPLES OF RESPONSIBILITY

Before I look at each of the principles, I write of my use of the terms 'principle' and 'belief' by using an example. I use 'belief' to represent something I can act on—I believe classrooms where students learn should be bright and welcoming. If I act on this opinion and find evidence and support for my belief or opinion, then it may become one of my principles of teaching—classrooms should be bright and welcoming for students. This remains a belief for me, as I have not searched my practice sufficiently for evidence or support.

The principles I discuss are ones I found significant evidence for as I worked with students in a teaching capacity, but there are limitations to the experiences I bring to my inquiry—I was working mostly with science classes in Australian schools from the 1970s until the first decade of the 21st Century. In the latter years of my career I was teaching classes of 20-24 middle-class girls aged from 12 to 18 years. It was in these classes the five principles became mantra-like, repetitively stirring my conscience of the role and responsibilities I had come to accept as mine when teaching. They are my expression of what my teaching had become—so distant from the years of the ‘faded green textbook’. But do not forget the ‘faded green textbook’—it has a role to play.

In one sense, these principles are not ‘mine’. Some reflect the general aspirations of Australia’s *Melbourne Declaration on Educational Goals for Young Australians* (MCEETYA, 2008), others recur in many science curricula, from the *Australian Curriculum: Science* (ACARA, 2017) to curricula developed at state, school or individual levels. What makes them mine is the authenticity that came because they evolved from my practice—from the transformations I saw as I worked with students and searched for insights into my own teaching.

In this chapter I explore each principle and the many decisions and evaluations I made so each one became mine and became an integral part of the living practice that guided my last years of teaching. I explore these principles using critical reflection and subsequent interpretation to help me understand and get a sense of measure of the value these transformations brought to me as a teacher and to my students. Many of the transformations evolved from my changing views of the purpose of teaching science that enabled me to make changes to the social order of my classroom (Biesta, 1998) that sometimes called for a reassessment of beliefs, feelings, and values from the past. My focus on the value change brought to me as a teacher I find particularly significant—often value is measured by the effects of change on the receivers of education and little attention is paid to the value or otherwise that might be brought to the teachers.

aSCuPTaS is a curriculum based on these principles, but my writing sees me sharing responsibility for them with primary teachers rather than giving them total responsibility or no responsibility, either of which could bring distress. I find to share is to bring the support we often see happening in our daily lives.

To share

Her mother asked for her room to be cleaned

The five year old retaliated with

Much stomping of feet

And wailing of I can't do this
So mother stepped in and said I can help
What if I do this and you do that.

It was over in thirty minutes
And they talked as they picked the
Bits and pieces from the floor.

Where did this come from?
Remember it came from
My house when I was as little as you
It was mine when I was small.
Yes, I remember the little brown rabbit
It is mine now and he puts it carefully on the shelf.
The room is 'done'—for a moment
Now the task was shared.

It only works if there is someone to share.

I wonder if Stroud (2016) might have found teaching easier if somebody had shared. I certainly would have liked to share as I negotiated my way through the changes in science education in the latter part of my career. I hoped this act of sharing might bring support to teachers as they introduced science into their classrooms. I hoped it would it help them understand the value the principles might bring to both them and their children. And maybe, it could help primary teachers say, I love teaching science and "this love motivates and sustains my commitment" (Whitehead, 2009, p. 94). And maybe, it brings the support primary teachers might need to undergo transformations that lead to substantive and sustainable change (Servage, 2008) to their beliefs about teaching science. My possible answers to these questions do not appear until Chapter 5.

Although I treat each principle one by one in what follows, it is important to avoid an artificially linear explanation. Rather, we should understand each one as interconnected with all the others and with the discussion of my next chapter. Before I begin, I tell another story, a tale of curriculum renewal.

Curriculum Renewal

A 'hallowed' room
Once removed—from classrooms
No students—a hushed respect
A select group–faculty heads
'Director of Studies'
And me—no title.

Consistency and frameworks
External consultant
EXPENSIVE
Equals important?
Recognition of
A need for change?

Three days
A change
Syllabus goes–curriculum comes
NO!
Syllabus stays—new framework
For consistency
For renewal.

WE STOPPED
Return to business
As usual
What did it mean?

So, what did this mean? I believe my disappointment came from the different perceptions of the words being used within this group of faculty heads—'curriculum', 'renewal', 'syllabus' and 'consistency'. My heart was beginning to move to the sound of a different drum, a drum whose beat may have quickened more rapidly than for others, especially as my changing views of a science curriculum that were growing from my 'lived experiences' of science in my own school days left me with a sense of being deceived (Gadamer, 1989, p. 357, as cited in Seidel & Jardine, 2014 p. 186). It was moving away from the dominant modes of curriculum in the 20th Century that suggest there is established, canonical knowledge that must be included in school curricula (Venville et al., 2009).

My use of the term 'curriculum' was taking on new meaning in parallel to my understanding of my role as a teacher. I understood 'curriculum' to mean something less clinical than its common meaning of a course of study in a subject or as a syllabus, a brief statement of the contents of a curriculum, or as something hallowed and remote from teachers—my ideas of a curriculum were changing from that of a dispassionate, remote object to something of greater familiarity, something that might teach as well as prescribe.

To find myself in this place had taken several evolutionary steps, but at the time of *Curriculum Renewal*, I could already envisage a renewed curriculum for science teaching that would not ignore the prejudices I brought from my experiences teaching and as a student, but would take me to a view from higher on the mountain, one that embodied that seen from below but brought into focus a bigger picture of a curriculum. Yet again, I compare my changing views with the horizons of Gadamer (1975/2004), who urges prejudices and pre-conceived ideas not to be a handicap to the subjective nature of hermeneutic inquiry, but as measures of the impact of something new and perhaps foreign—my work with Year 7 and 8 classes had already given me a sense of the 'good' that could flow from my changing views.

My horizons had perhaps moved further on the continuum of curriculum change before this discussion of curriculum renewal. They had moved to a point where I often questioned the canonical content emerging from this process and asked where is the pedagogy and where are the connections. My shifting horizons may have resulted from having more opportunities to find, "a space in which the bonds of truth can be rewoven, in which we can seek truth and truth can seek us" (Palmer, 1983/93, p. 70). I speak of how the relationship between curriculum, and therefore curriculum-writer, teachers and their students might be re-established through a curriculum where the need for energy flow is recognised (Whitehead, 2009).

But my horizons had also moved because my interest in curriculum renewal had been aroused. If this interest had not been present, I may have been content with the process of curriculum renewal I had witnessed (Gadamer, 1975/2004)—

if I had not so easily connected to how much richer my own education may have become in an environment where more trust was given to a holistic, all-inclusive view of the world of science. What I was seeing in this curriculum renewal was the contradiction of not being able to live my changing values of science education as fully as I imagined (Whitehead, 1976, in Whitehead, 2009, p. 88)—or perhaps curriculum renewal was only ever intended as a “a re-formation of the same clay or stuff of schools” (Servage, 2008, p. 73) not the transformation I might have imagined.

My hope is that aSCuPTaS may help re-establish these bonds of truth by its embodiment, directly or indirectly, of the sentiment of these five principles and the shared responsibility that would accompany this curriculum for primary teachers and their students. In the following sections I look closely at why each principle became significant for my teaching. For each of the five principles I have initially stated my belief and have concluded with a statement in my own words except for the fifth principle.

TRANSCENDING THE BOUNDARIES OF FRAGILITY

Principle: I believe one focus of science learning is on the development of a deep understanding of significant science concepts.

I ask why deep understanding, what are the significant concepts of science and who makes these decisions, and what role might a curriculum play in the communication of these ideas? ‘Deep understanding’, ‘significant science’ — these words resonated with me when I first read them (Blythe, 1997; Wiske, 1998). They stimulated more reading and an exploration of the Teaching for Understanding website (www.pz.harvard.edu/projects) and those who had contributed to putting together ideas that would become significant in my education world. It made sense to understand and to understand deeply. But what does it ‘really mean’ to understand and to understand deeply?

I took my cue from David Perkins (1993) who describes knowledge as fragile when students are unable to grasp meaning and cannot apply what is studied. Fragile knowledge, shaky knowledge—the knowledge you hope no-one challenges beyond the surface because you stand on ‘shaky ground’, so to speak

—bluffing, faking, pretending you know something and you do not know much. Fragile, like Easter eggs, easily cracked to reveal an emptiness inside.

I begin to think of the ongoing war in Syria and chide myself for my fragile knowledge.

War—that finds no place

Syria—a place
Fragile knowledge
One or two details
Of names
That come from news reports.

Understanding
Superficial
Causes, possible solutions
Effects they bring to the future.

War—as emotion
A deeper understanding
Hurt—physical, emotional
Limbs and hearts
I think about the children.

Damage
Infrastructure, homes, economies
Animals, vegetation
Where will we live?
What will we eat?
I think about the children
The future.

Wars stop—they do not go away
They stay—for a long, long time.

So perhaps I have more understanding than I thought, but not of Syria—that remains a fragile knowledge. My understanding is about concepts of war gleaned over many years. Of course, I can supplement my fragile knowledge by going to the Internet to find some missing pieces but I must ask more questions, deeper questions—how has the deep mistrust between the groups in this war developed? Who is controlling the war and how is it paid for? I chide myself still and vow to ask these questions, to find a way to understand this war.

So, the notion of war without it being a 'particular' war is what I began to call a 'concept'. Wood (2008) refers to Carl Wieman, a physicist-educator and recipient of a Nobel Laureate award, who talks of concepts as facts that can be applied in multiple contexts to explain and/or predict outcomes. My notion of war is such a concept, one I bring with me and can use in many situations, but I understand the good that can come from being more familiar with some of the facts about the Syrian war.

It is a little like the situation I found when I studied BSCS (https://bscs.org) biology in Year 12, and spoke of it being like an intelligence test—an intelligence test that left me scrambling to find high school biology books to get some of the facts when I began at university. There becomes a question of when do concepts become facts? Wood (2008) explores this question, indicating the more you burrow into science the more factual what you find becomes—it is why I turn to the Internet to find the names of the enzymes controlling Kreb's Cycle.

Alfred North Whitehead expressed similar thoughts in relation to university students,

> Your learning is useless to you till you have lost your textbooks, burnt your lecture notes, and forgotten the minutiae which you learned by heart for the examination. What, in the way of detail, you continually require will stick in your memory as obvious facts like the sun and the moon; and what you casually require can be looked up in any work of reference. (1929, p. 26)

I start to think about science and science teaching and the place of deep understanding and the place for facts. I find both relevant, although I would always prefer the balance to be skewed in the direction of understanding concepts and exploring the idea of concepts.

We live in a world where our collective knowledge is growing, becoming impossible to remember the detail of the knowledge we live with. Fortunately, this detail is becoming easier to access, unfortunately this is not always for the 'good' and we must learn to trust our sources—this has its own story. It is perhaps less important for us to crowd our heads with this detail and make more room for the more valuable concepts. Of course, it is useful to remember some details but as Whitehead (1929) implies, the details we use most frequently we will remember and, if we are working in a specific discipline, we will remember vast amounts of information relevant to what we are doing.

I add a short personal story, possibly the source of my "already operating intimacy" (Seidel & Jardine, 2014, p. 60) with concepts and facts and the living contradiction (Whitehead, 1989) that existed in my own learning that enabled me to immediately connect with the notion of concept.

Barbara

Shall we take her to Australia
No eleven plus
No Grammar School or Secondary Modern
Comprehensive High Schools.

It was not the only reason I am sure
But it lingered somewhere in their minds!
After the struggles that came with
The kings and the queens and the dates.

"And the king asked the queen and the queen asked the
PROMPT—dairymaid
"Could we have some butter for the
PROMPT—Royal slice of bread?"
The continents, the countries
The constellations and characters
From history …
And so it went on.

And I went to comprehensive school
In Australia—to put their minds at rest
About my prospects
But I was successful—when facts were not involved

It’s so much easier now
With the Internet
And husband to remember the facts.

It’s not just old age I tell myself
It’s just me—it’s who I am.

And yet, I believe the process of memorising still figures highly in science education. Even in my Year 7 and 8 classes much of what was required was the “minutiae which you learned by heart for the examination” (Whitehead, 1929)— details easily marked because of the objective nature of the questions—‘good’ for the teacher, but is it ‘good’ for students? But, if this memorising of details is becoming less important and the sheer number of details is beyond possibility to remember, what should we focus on instead? My answer, like that of the Teaching for Understanding (www.pz.harvard.edu/projects) team and others who are promoting an emphasis on concepts, is that we should focus on understanding significant ideas because, to “develop understanding of scientific concepts, explanations and theories enables people to explain and predict natural phenomena and to apply that knowledge and understanding to new situations and events” (National Curriculum Board, 2008 p. 5).

In my last years of teaching, I started to think in terms of significant science and the reshaping of the content of my Year 7 and 8 classes—making it more robust and giving my students opportunities to escape the net of fragility. I began to identify significant science concepts and separate them from the trivia. My purpose became more focussed, my questioning increased and became more considered—the path I was taking to help my students understand about science assumed greater clarity. It was not a straight path but one diverging right and left to pockets of interest or that momentarily stopped—a break to sit and take in what was around, before returning and continuing our planned route. This focus on concepts gave more space, more time, for students to contemplate the stories of science unfolding and to feel the fabric of the story that “pulls each of us differently as we each pull it from here and there” (Seidel & Jardine, 2014, p. 59). If one of us fell by the wayside there was a space to talk of what we did when they missed our journey—what we had seen and what we had heard. I write another story to bring meaning to these words.

Where do the apples come from?

Year 12—my daughter—my class
Biology
Where do the apples come from?
Year 12—genetics, meiosis, mitosis, DNA, protein synthesis
I hear it again
Where do the apples come from?
And frown in disbelief.

Until now—flowers overdone
Year 3, Year 5, Year 7, Year 9
Collected, pressed, drawn,
Labelled, dissected,
More than once.

Tested—perfect
Purpose—no connection to
The bigger questions.

Where do the apples come from?
I think of a map
I think of a curriculum

This story suggests the need for planning, a map, a destination—the concepts of science. In this case concepts such as: living things reproduce, plants and animals reproduce in different ways and flowers are the reproductive organ of the flowering plant where seeds are produced. The connection between flowers and seeds to reproduce can be applied throughout the flowering plant group—one important piece of information, a concept, that can be applied to roses, gum trees, grasses, to all flowering plants.

We need to know our starting point, where we will meet and what we bring. If we do not know our starting point and have no planned route we begin to wander, we lose our sense of together and it becomes more difficult to find a member of our group who might become waylaid or lost. If a clear map for the journey into living things had been available, my daughter's teacher may have found her lack of connection between an apple tree's flowers and its fruit, apples.

To develop a plan and map the journey so we might identify an order in which these big ideas might be introduced could help to build a growing picture that gradually opens wider vistas. Perhaps not an itinerary, a detailed plan for a journey, more of a 'mud map', an Australian name for a map drawn on the ground with a stick or any other rough sort of a map. Mapping the journey I wanted to take with my Year 7 and 8 classes was difficult and time consuming, requiring many decisions to be made about science, particularly the significant content of science and the gradual unfolding of a much deeper understanding of science beyond what might happen in your classroom.

In the very early years of primary schooling, teachers begin a more formal journey into science education than the one some of their students might have experienced in their pre-school lives—a beginning where the 'seedlings' are young and vulnerable, the opportunities for their growth critical. There is perhaps more inconsistency in these young students than I saw in students coming into my Year 7 classes—perhaps less known of the embryonic growth beneath the ground before the emergence of the first leaves.

The success of this journey into science is set in these early learning years, dependent on the nurturing of the seedlings, the sharing of the knowledge children bring with them and the care they are given. It is perhaps better not left to chance but neither should it be autocratic and authoritarian. It ought to be a gentle, encouraging and engaging journey. I begin to consider who takes responsibility for the journey and recognise that as curriculum-maker I would share my role with primary teachers and take dual responsibility for the 'good' of our students by combining my strengths in science with the pedagogical strengths of primary teachers.

With the help of the *Statements of Learning for Science* (MCEETYA, 2006) I spoke of in Chapter 2, I would communicate with primary teachers the significant science for students to learn in their primary years, concepts that can be applied to more than one situation—ideas worth understanding. I would introduce questions that encourage teachers and students to delve further, more questions would be evoked as conversations unfold, and I would write some background to the science. I would do these things because I had the time and a science background that enabled me to do it, but I do it also because of the value I place on primary teaching and the trust I have in primary teachers. I do it in the hope my actions might support primary teachers focus students' learning without the distraction of unnecessary details that prevent opportunities to dwell in the science of big ideas. I do it in a way that shows I understand primary teachers by focussing on significant science that can be fitted into the overcrowded primary curriculum without losing opportunities for children to begin to burrow into science and think about the place it has in their world.

But none of my actions would be effective if I did not talk with primary teachers in the way I had learned to talk with my classes as a teacher, because this would be my way of taking pedagogic responsibility and acting with pedagogical tact (van Manen, 1990) and establishing a community of truth and trust between me and primary teachers in the way of Palmer (1983/93, pp. 47-68).

I see only 'good' could come from aSCuPTaS, a curriculum based on the principle of 'deep understanding'. The 'good' for me is that science teaching would begin in primary schools, a factor I valued, and the 'good' for primary teachers would come from their journey being planned so they saved time and had a clear vision for the path they would be travelling, giving them a space where they can decide the pedagogical details of the.pathway they will take..

For me as curriculum-maker, I accepted responsibility for mapping the content of the *Statements of Learning for Science* (MCEETYA, 2006) to fit the purposes of aSCuPTaS—this would become my biggest role.

I'll keep you company as you dig deeply into the web of science—each digging brings another piece to add to the image of greater understanding.

THE CREEPING EDGE OF AN INTEGRATED CURRICULUM

Principle: I believe that science knowledge emerges most effectively from a disciplinary base but I encourage a holistic view of science

I ask why I believe in a disciplinary approach to science teaching and whether this can be achieved whilst maintaining a holistic view—two quite diverse ideas—and what role a curriculum might play in supporting both. I have come to believe that from quite early in primary schools there is a place for science-focussed learning—a disciplinary approach where there are few distractions. This has not always been my view and is one that might sit uneasily amongst other teachers and curriculum-developers. Like many science teachers I have found reaching the firm view I now hold has been quite challenging, and has seen me swing from one extreme to another before finding a position I believe in. I was not alone in feeling challenged. Grady Venville, John Wallace, Rennie and John Malone write, “Integrated curricula challenge many aspects of established practices, rituals, beliefs and hierarchies of traditional school establishments” (2002, p. 77). This wavering between a strong sense of subject and the implications of integration for science teaching and science becoming a truly integrated part of the curriculum has continued to bring tension in Australia. Venville, Rennie and Wallace (2009, p. 6) identify seven “points of tension around which the issue of curriculum circulates. The first point of tension is that curriculum can take the form of a discipline-based approach or an integrated approach”. In the following writing, I question my initial perceptions that science could be learned as part of an integrated study, something I had originally accepted as a given reality, an unquestionable truth, but began to see as a heavily mediated appearance “of reality and, thus, as convictions in need of examination, interrogation and elucidation” (Maclaren, 2015, p. 374).

At one time, I was a strong advocate of integrated learning that included science from primary to mid-secondary school. Experiences in the early years of this century persuaded me to re-imagine my view, but I remain in favour of integrated study—for some purposes. Now, I believe the teaching of science concepts using an integrated approach is not easy to achieve successfully. To express this view so strongly is not consistent with the views of some others, particularly James Beane (1990/1993) and Kath Murdoch, (1998), whose ideas I originally espoused. I reflect on my metamorphosis.

A question of value

A workshop

Thank you, Kath Murdoch

Hooked on

Integrated studies—the merging boundaries
Possibilities—opportunities
Thank you, James Beane.

2003
Parallel Studies
Thank you to the principal
An opportunity—for me—the students
Four periods a week so much to do.

Grim faces from the faculty heads
Lost time
Make it up—make it up
English focus, maths focus, science focus
Help—it doesn't work like this
Elements of doubt?

Two years
A new name
The Compass Program
Less time—more adventures—more excitement.

Models—discussions
Drama—music
Poetry—prose
Art—and a circus

Values, values, values
Memories—education—shared spaces
Diversity—forests—change
Engaged—high calibre—different.

Two years
Retired

Metamorphosis complete.

To explore the possibilities of integrated studies was a welcome gift—but not one given without payment in return, it came with conditions. The focus of each topic was to be determined by faculty members as reimbursement for time lost from English, mathematics, science and studies of society and environment (SOSE). The presence of these conditions made me reassess my belief that science could successfully become part of integrated studies until well into secondary school.

It doesn't work like this

Together we planned
A science-focussed unit
The nervous system
For integrated study
Memories.

Amongst the debris of
Photographs, trinkets, stories and tales
Shut your eyes and imagine you are
Three years old, seven years old
Imagine you
Last year, last week
Are there memories there?

Amongst grandma's crockery and christening gowns
Uncle Jack's walking stick—and his medals
The tickets, certificates, cards and
The music you played
The memories came
And then …

Came the brains, the scalpels, the microscopes
And possibly white coats and goggles
The paraphernalia
And fragile understandings
Of the nervous system.

It doesn't work like this

To include science in this field of integrated study appeared artificial and brought an inauthentic note I found discordant to my ears because it was not doing justice to the teaching of science, but I grew to understand it had another purpose.

As the program evolved and became less influenced by the concerns for 'lost time', I sensed this changing purpose of Parallel Studies. By the time I left teaching, the integrated studies program had evolved into a range of topics that focussed on 'values'. My vision of integrated study had grown to one of opportunity to bring together ideas and knowledge students already had—knowledge learned from their life experiences or those of their fellow students in formal or informal situations. It was an opportunity for them to develop a more encompassing view, a way to explore and challenge some of the 'big questions' students have about life—questions that for me became ones of 'value'. To have a place for integrated studies in parallel with a disciplinary based program of science provides a possible way to resolve the second point of tension of Venville et al.,

> The second issue is that real-world science includes a number of complex 'scientific perplexities', including environmental sustainability, that are difficult to consider from within a single discipline and, at the same time, require a depth of knowledge from a number of disciplines to understand. (2009, p. 6).

The diversity of learning that was taking place in these units demonstrated the power that integrated learning could bring to complex issues that might emerge from science or other disciplines. I believe it also brought a different way of thinking about the methods that might be used to bring knowledge and understanding to these complex issues and the purpose of integrated study relative to the study of a specific discipline. My purpose as I introduced the Parallel Studies Program was to create a way for students to become immersed in exploring the values and ethics that need to be considered to find some possible answers to the complex, big questions present in our society. The method that emerged as my colleagues and I worked in this area became one of taking the collective knowledge of the students in the group as a starting point and from there working outwards to reveal a bigger picture that might bring possible answers to questions that have no answers—questions of value.

In this example, I take the collective knowledge of memories to introduce questions that would stimulate students' understanding of the value of memories—what would it be like in a world without memories? It gave opportunities for students to engage with and talk about memories, think about memories and explore their memories from many directions using knowledge they already had, knowledge arising from their personal 'lived experiences' rather than formal education or knowledge brought from the discipline areas across the curriculum. I understand my way of working was in many ways hermeneutical in nature involving reflection and interpretation of this collective knowledge base. The ripples of learning were moving outwards from the familiar to a more encompassing understanding—understanding that came from a predominantly subjective base quite different than that of science.

Within the discipline of science, my purpose was different, emphasising the development of a deep understanding of significant concepts and the ways scientists investigate to know how things work—what we might think of as canonical or traditional science. But my purpose was also to bring a deeply human side to science that has the potential to engage students to interact more intensely with these significant science concepts by paving the way with familiar or contextual science—how science influences our lives, its history, the problems it has solved and the problems it can cause, the ethics and values of science. Together I found these ideas made science, particularly in my Year 7 and 8 classrooms, live. Once engaged with the science, the ripples of learning would move inwards towards a deeper understanding of significant concepts of science. It would take a lot of persuasion to make me think that the living science I could see in my Year 7 and 8 classes could be replaced by the artificial science I saw when we tried to slip it into our integrated program—each has its own place and purpose.

As an analogy, I think of integrated curriculum as more like searching for connections in a complex environment in the way of a physician, whereas disciplinary study is about exploring in depth one area such as science in the way of a medical specialist. It is their broad range of expertise that differentiates general physicians from those who limit their medical practice to problems involving only one body system or a special area of medical knowledge. Physicians provide a global approach to diagnosing complex medical problems and need to know about a wide range of diseases, unlike specialists whose enormous knowledge focuses on one specific area.

Whilst this analogy is some distance from the classroom, I believe it reveals a place for both integrated and disciplinary based study in schools. My experiences with Parallel Studies leave me unable to visualise teaching and learning science in a fully integrated environment, like that originally proposed by Beane (1990/1993) or like the proposals Venville et al. (2009) list, which call for the integration of science.

Venville et al. (2009) allude to the time factor and other impediments to implementing integrated curricula as a cause of tension in the debate over integrated versus disciplinary science education. In Australian primary schools Angus et al. (2007) recognised the difficulty of reducing the crowded primary curriculum through an integrated curriculum because of the time it would involve. To reduce the crowded curriculum was one of the purposes behind the development of *Primary Connections* in 2005, a program aimed to connect science and literacy. More recently, Jennifer Nayler (2014) proposed a 'purposefully connected curriculum', one that draws on two or three curricular areas of the *Australian Curriculum* (ACARA, 2017) which might be quite difficult unless contracted to outside developers. Anna Faccinetti (2015) introduces a professional development resource for integrated learning across science, history, geography, economics and civics and citizenship that has been created by outside developers Amanda McCallum and Karen Green. In Faccinetti's 2015 article McCallum and Green have said they produced this program because they recognise the difficulty of writing integrated units perhaps like those suggested by Nayler (2014) because of the time needed, time that might be better spent by primary teachers' presence in their classrooms.

None of the ideas from Beane (1990/1993), Murdoch(1998), Nayler (2014), McCallum and Green (as cited in Faccinetti, 2015) or others less familiar, are foreign to me nor do I dismiss them. The essence of our common interest in integrating curricula from the different disciplines in schools perhaps comes from our concern for the wellbeing of primary teachers and/or their students. The concept of an integrated curriculum that had aroused my interest (Gadamer, 2004, p. xxxii) was challenged by the living contradictions (Whitehead, 1999) I experienced when I found myself in the space of an integrated curriculum that became something my original vision of Parallel Studies had not anticipated—one driven by a specific discipline. This accidental opportunity gave me a chance to ponder my thinking and left me with a strong belief that integrated programs have an important place in any school curriculum but not for learning science. I remain skewed towards science learning emanating from a disciplinary base because of my strong belief in the value of science in primary schools and my uncertainty about its successful accommodation in an integrated program.

The question of integrated or disciplinary approaches to science learning is difficult and one that remains open in the *Australian Curriculum: Science* (ACARA, 2017), "no preference is given about whether science learning be addressed from a disciplinary or integrated approach and there are tensions around this topic" (Venville et al., 2009). But, aSCuPTaS is a science curriculum born from freedom, it represents my dreams and I have taken the liberty of expressing my preference for a disciplinary approach firmly. To treat science with respect for its individuality comes from the truth of my heart, a truth that calls science teaching to focus on science—the truth that has come from my experiences with Parallel Studies. But my heart also tells me that whilst the essence of science may be contained, its strong roots will escape the permeable fabric that surrounds it to pervade the greater environment—if permission is given.

These strong beliefs place substantial responsibilities on me as curriculum-writer. In addition to accepting the identification of science worth learning, I accept responsibility for making both implicit and explicit connections between science and other disciplines. When I began focussing on Year 7 and 8 science teaching the opportunities to make connections grew once I broke away from the growing notion of science as investigations in 'lab coats and goggles'. Many of the connections come from the use of skills developed in other disciplines including the arts, numeracy and literacy, history and technology, particularly when teachers use these skills to engage students with science or as students communicate their ideas about science, its values and concepts.

So, whilst I call for science to remain an individual discipline in primary schools, the creeping edge of an integrated curriculum had taken hold of me and disturbed any thoughts I might have had of canonical science. For me, science teaching could never again be anything but one that espoused the characteristics of holistic science and "involve students looking towards multiple dimensions that reflect the real world and are not bounded by the disciplines" (Venville et al., 2009, p. 1). I take these ideas with me to the following section.

But whilst I take responsibility for writing aSCuPTaS as a science curriculum to be approached from a disciplinary base because of my experiences in Parallel Studies—the difficulties of being faithful to science and the difficulties of being faithful to teachers because of the time it takes to even attempt to bring science into integrated study—I remain adamant that generalist science teachers should take responsibility for teaching science and for continually making connections with other subjects, because to learn a holistic science is part of what I understand as the purpose of science teaching in primary schools.

That which we come to know may be plucked from a field of science—but it is a field
where the boundaries are blurred and voices call to keep in mind
a bigger space we call our world and what might be beyond.

LURING CHILDREN INTO THE INTRICATE WEB OF SCIENCE

Principle: I believe all children need to be invited to explore the intricate web of science.

I ask how this invitation might be posted to all children and explore the role a curriculum might play in supporting teachers to send these invitations with love.

Some of this chapter speaks of pedagogy, which I consider more thoroughly in Chapter 4. In this section I talk of extending the boundaries of science to include human connections that may lure more students into exploring and understanding the intricate web of science. I speak of 'science as a human responsibility' (SHR) rather than 'science as human endeavour' (SHE)—the description used in the *Statements of Learning for Science* (MCEETYA, 2006) and the *Australian Curriculum* (ACARA, 2017) because I find it reflects my vision for aSCuPTaS more clearly. Marianne Logan (2012) writes that in a small study of primary teachers she found,

> some innovative approaches for integrating SHE elements into science lessons but also teachers' concerns about addressing these elements. These concerns related to lack of familiarity with the strand, assessment of SHE elements, and the

> perceived inability of the primary and junior secondary students to be able to understand the sophisticated ideas surrounding SHE. Teachers believed that support would be required to assist them to address the SHE strand and to be able to break down these aspects in order to promote primary and junior secondary science students' understanding of these elements. (Abstract)

I too had found the ideas of SHE rather vague when I first saw them expressed in the *Statements of Learning for Science* (MCEETYA, 2006). My first interpretations of SHE I have now explicated and extended to become my vision of SHR. In SHR I speak of history, of science as it affects our lives, of notions of science as it relates to the world, of our responsibilities (ethics) when science is used and our respect and responsibility for the things that science cannot explain. Or perhaps I should say the responsibilities those who engage with science need to take for the living and non-living elements of the world. It is an untamed description I find difficult to express succinctly — it is science beyond a science many would see as a part of a science curriculum but it is science as it appears in aSCuPTaS because of the purpose of science in primary schools as I see it. The idea of SHE has stayed alive as SHR and speaks of the 'good' these human connections and responsibilities might bring to the world of science by luring more students to engage with a more traditional science knowledge. I begin by recalling my interactions with science at school.

A sense of science

Science
In primary years, a little
Science
At the whim of the teacher
Chance
But warm—stories
Of Pasteur, Jenner,
Stephenson People—medicine
The 'Rocket'
History.

Helpful science
A sense of science
A sense of mystery
A suspicion
Of what might come.

If only I had known!
The dreariness of secondary science
Few memories—each the same
Except on Wednesday.

A practical lesson
Rolling balls—bomb calorimeters
And mercury I do remember
Red powder to silver ball
A lonely magic moment in science.

A report to write
More listening—more notes
To learn
Books full.

No connection—to me
An accidental student
Misplaced—a quirk of testing measures.

Languishing now in physical sciences.
If only I had known
The gifts that might have come
From the biology stream.

An accidental student in physical science classes, I came with no innate interest in knowing the content of the curriculum in those long-ago days—it offered little that lured me to make connection with test tubes, Bunsen burners, inclined planks and pendulum bobs. And yet, I might have become involved if only one of my secondary teachers had dared to make the physical sciences live—perhaps they felt "bound to the said and what constitutes the rein of the speakable" (Myer, 2010, p. 87). The physical sciences may have spoken to me if they had taken me to a place beyond the light globe and how it works, beyond the extraction of copper from its ores or beyond gravity keeping us firmly connected to the ground. They might have tempted me by asking, how has the electric light changed our lives, what is so good about copper that we want to extract it from its ore like Neolithic man when they mined native copper and used it instead of stone? I might have been pulled into science had they asked how mining copper or coal or oil or uranium might damage our environment or brought destruction beyond Hiroshima—these living links to history, humans and the ethical nature of science might have been the invitation I accepted.

Perhaps if I had been asked to do something with the science—to plan a gravity-fed watering system or a way to filter pond water so it was drinkable, to solve a problem or ask a question—I might have become more absorbed and interested in the physical sciences. I was unlucky to be excluded from the biological sciences I would grow to love when the opportunity came. All secondary students and primary children need opportunities to find the meaning science has for them, to feel in their hands not only their heads, what science might bring. I believe these opportunities ought not to be left to chance.

When I reflect on these experiences I find myself responding in the way of Seidel (Seidel & Jardine, 2014 p. 137) who talks of the responsibility teachers need to take to avoid crushing the wonder of a child's experiences and the faith and trust they have in their teachers. The warmth and wonder of what I was beginning to recognise as science in my primary years, my developing curiosity of the world around me was quickly extinguished by the monotony of being 'the receiver' and never 'the actor' in my secondary years—crushed until my undergraduate years when the wonder slowly began creeping back as I found myself exploring a new world of genetics and biochemistry. But my wonder of these sciences was stimulated by the content rather than any thoughts about the possibilities of this science—I remained mostly in the position of receiver, not the asker of questions.

My first years of science teaching made me wonder why I had chosen it as a career, as I made my way through the rather dull but peaceful early years of teaching science. Then in the mid to late 80s life started to flow into my chosen career. It was not wonder at the world but wonder at the difference my teaching could bring to my students and wonder how my feelings for teaching grew as I sensed my pedagogical responsibilities growing and watched my students being lured into learning. This breathed a sense of purpose into my teaching, a sense of what it means to teach and what it means to have the energy to teach.

When I look back on my career, I recognise my first, rather clumsy attempt to change my pedagogical approaches and deliver an invitation to my students. It was not in a science class but a Year 10 mathematics class. I tell this story because it brought new meaning to my teaching.

Repetition to revolution

The usual
Disengaged students—'low ability'
Gathered in a class of no future.

Measurement—angles, distance,
Scale and time
Textbook–Chapter 6
How to measure an angle,
Exercises on measuring angles
Purpose?
Measuring and angles
Ditto
Measuring distance
Ditto
Measuring time
Ditto
Using scales
Purpose?
Measuring.

The new—orienteering
Innovative for 1987
At my school
Using maps—making maps
Using stop watches
Using compasses
Calculating distances
Calculating elapsed times
Occasional exercises—from the text

Frequent exercise
Orienteering.

Purpose—measuring
With hands and heads
Community—action—health
Outdoor life.

I see them still
Sometimes—forty plus
They say, do you remember
The time we went
Orienteering?

It was not the nature of the activities I was using to engage students with mathematics or the widening of the context of mathematics that touched me but their response as I extended a welcoming hand to gently ease them into a world of mathematics from which they had possibly been excluded for many years—moving from the turtles, to snails, to sloths of primary schools, to find themselves condemned to 'general maths' or in the vernacular 'dummy maths' in secondary school. I was reaching out to these students, connecting their learning with reality so that they could see purpose in what they were doing—a purpose that brought them the energy to continue (Whitehead, 2009). This mix of purpose, real-life and carefully selected activities was a strong motivator, a powerful incentive to become involved. It seems so obvious now, to make these pedagogical choices—it gave them purpose, it gave me purpose and a sense of common ground, of communal ground that we shared. It was enough to make the offering of invitations part of my conscious teaching practice. Whitehead writes,

> I found my imagination worked spontaneously in generating ideas about how I might improve my practice. I consciously chose one possibility to act on and formed an action plan. I acted and evaluated the effectiveness of my actions. In 1967 I followed this action reflection cycle intuitively as I began my work in education and only made it explicit later. (1976, cited in Whitehead, 2008)

My students faced the customary examination, sitting in serried rows of desks in a cold, bleak hall, invigilators stalking past—some passed with credit, others passed and others failed as might be expected in a 'norm' based climate but they had been interested, tantalised for a moment or two. I liked what I saw—their learning how mathematics might be used, becoming involved beyond the textbook and developing skills not mentioned in the text, working together, to support each other and interacting freely with me, their teacher. It was different.

Maths of no measure

No measureable outcomes
Of what it really meant
Just purpose
Community
Support
And energy
Unmeasurable feelings.

It might have been different
If it was a class of 'gazelles'
It might have been different if I captured an image
Of what it was like
As they joined me
In this adventure.

An adventure in humanity
In mathematics
Another beautiful risk.

Much of what I speak cannot be written on the 'paper' of a curriculum as easily as the knowledge of subject. It is dependent on teachers and the choices they make that I trust to breathe life into their teaching of science so they can lure their students into the fascinating web of science without snuffing the wonder of science in primary schools. As curriculum-maker I take responsibility for communicating as much as I can about SHR in aSCuPTaS and I have faith that with guidance, primary teachers will be able to lure students to engage with science by bringing a sense of humanity. This principle becomes one shared in execution between primary teachers and curriculum-maker.

I'll help you have confidence to play your magic, but leave you to pen the invitation and
cast the line that lures your students to explore the paths of the
intricate web of science.

COMMUNICATION AS ASSESSMENT

Principle: I believe the assessment in students' primary years of science should be formative as students learn and demonstrate their understanding of science by being given opportunities for communication.

In this section I reflect on the personal experiences that help me understand why and for what purpose formative assessment became a principle of my teaching practice in science that intimately entwines assessment with communication. As I write I also consider how responsibility for this principle might be shared between curriculum-writer and primary teachers and see how closely the narrative and my interpretations interweave with those of my previous section. I separate them out of respect for the individual worth each brought to my teaching.

The three short pieces I write come with many similarities to those in other discussions in this chapter. They relate to the 'good' I saw when I changed my practice and the positive impacts this had on my students and on me. They also hint at the frustration as messages change, progress drifts around the 'norm' and purpose becomes forgotten. Biesta (2009) asks, "How, then, can we bring questions of purpose and direction back onto the educational agenda?" (p. 38).

The question of formative

Thoughts of formative assessment
Began some years ago
Assessment to help you learn
No longer a letter or number that
Appeared on 'the report'
A letter of what took place in one term
Or perhaps one year.

The letters and words of
Formative assessment
Struggled daily, weekly, frequently
From fingertips—of teachers.
Hours of marking, words that tried to help
Encapsulated in red penned scrawls
Grown from late nights that ran to early morning
Tired eyes and coffee cups.

Writing that might humiliate
Or praise—if read aloud
Writing left unread by some
Who found no reason
When it came on the wrong side
Of the event where it began.

But all things change—in education
Criteria came—for good reason to steal
Disturb the peace of science
I am not sure much changed.
Something wrong remained I thought
With this narrow hidden voice
Of the formative assessor—in science.

Talk of changes in assessment began to reach me in the mid 1980s, it focussed on a division between formative and summative assessment. Royce Sadler (1989) defined formative assessment as assessment that helps students improve their competency by focussing on what needs to be done to help them achieve specific outcomes and summative assessment as a summary of students' competency at a set point, the end of a year or the end of a course. There was consensus that formative assessment could bring significant benefits to students' learning (Sadler, 1989) by providing feedback on performance to improve and accelerate learning—feedback particularly in the form of written comments tailored to students' needs rather than a single mark or grade that appeared after the teaching and learning was completed. Ideas of this sort failed to touch my heart, especially when interpreted in ways that brought much more work to me as a teacher, such as, marking to be completed within two days and to include thoughtful comments and suggestions'. I failed to see these ideas changing the purpose of assessment from the one of cultivation of the fittest in science that had existed for many years. Comments made to individual students seemed wasteful, and yet the concept of formative assessment appealed.

As I began to understand the possibilities formative assessment could bring, I found ways to include it in my practice that made more sense to me. Many of the ideas I speak of came through Education Department workshops where my interest was fuelled by the work of Lorna Earl (2003), particularly ideas of assessment 'for' and 'as' learning. As I reflect on how I began to twist together the parallel threads of communication and assessment, which would find a prime position in my classes, I found I had drifted away from some of Earl's developing ideas (2006, 2009), particularly the notions of separating 'as' and 'for' learning and had returned to the earlier more general view of formative assessment.

These ideas of formative assessment touched seeds of hope already sown. Seeds waiting for water to begin a journey that might release them from the confines of the narrow assessment practices in science, which gradually excluded the struggling seedlings from those strong and healthy ones which would grow into fine specimens of science. My introduction to the ideas of formative assessment awakened my dormant state because there already existed an "enthusiasm to be open to new possibilities" (Gadamer, 2004, p. 4 in Regan, 2012, p. 293) and took me to a sustaining light that brought new energy to my pursuit of a different dream of assessment and what it would become in my classroom. It was a revelation, a transformative moment, that brought significant change to my practice and understanding of the purpose and possibilities assessment could bring to students in a science classroom.

Seeds sown

I listened to those who knew of secrets
Unheard in science and spoke of dialogue
Of words that spoke aloud.

Seeds already sown unfolded from my darkness
To find a way to grow.
Struggling first to tentatively reach the light

That brought new growth in tender shoots
To become stems and leaves
That fed the inner core
And brought an energy to find a place
Of new found opportunities.

Soon I watched a dialogue
As each one found a place for passions
And I found a space for pedagogy
Of conversation and opportunity.

Opportunities to weave connections
Opportunities for gentle support
Opportunities to release the truth of who they are
Of who I am—opportunities for respect.

An emotional sensitivity infused this place of science
Students flew beyond the art of words
To dance and art and music
Skills and talents emerging not from science
Talents rarely found a place in my earlier teaching career
Or in lab of science—fixed benches—three-legged stools.
Language, illustration, drama, music
Sensitivities from the arts.

Practical skills—construction, engineering and computing
I only dreamed of in those earlier days—of technology
Many who brought gifts were humble
Hiding their light under a bushel
Keeping qualities and abilities secreted
People—like Mary—I speak of next
Not hidden purposefully
Hidden because there had been few opportunities
That let them be revealed.

I watched the energy the introduction of foreign fields of communication brought to my students in the name of assessment—energy to engage students, space for them to indulge their talents. In retrospect I recognise I was beginning to bring ideas of STEM and STEAM, particularly ideas of engineering and the arts, into my teaching practice. My purpose was to give students opportunities to differentiate the product used to express their learning (Tomlinson, 1999)—something I had been reluctant to do in the deep understanding phase of learning and teaching about science. I had found its place now. Differentiation of the product provided a wealth of opportunities for students to sometimes choose how they might share what they have understood about the science they have learned and another chance for me to help those who had not yet understood. It brought a space for students to develop social skills and the place of responsibility that comes when working personally or within groups.

Later in my career I became more able to elucidate another layer to my purpose in adopting this principle of 'Communication as Assessment' in my practice and aSCuPTas. This purpose is subtly different but immensely important. My purpose was to bring voice to students who may understand a great deal about science but have been robbed of opportunity—like my student Mary, or Eric whose writing Jardine shares,

> once upon a time ther was a rain drop and it gope on a bird then the sun trd into a watervapr the radrop fad his bovrsrs and trnd into a fofe white cloud and then it trnd in too a havie plak kloub and then it trd in bake to the same radrop and gropt on the sam bird. (Seidel & Jardine, 2014, p. 54)

I do not quote Eric for the same purpose as Jardine, but Eric's writing touched me and illustrated my purpose beautifully. Mary's writing skills may have been nearer Eric's six-year-old word processing skills than the peers in her class, but the message from both Mary and Eric do not disguise their understanding—messages I might have missed in the past.

The Conundrum of Mary

Mary—I remember Mary well,
Not her real name, a quiet student, rarely speaking voluntarily
Sliding in and out of science
To literacy and numeracy support each week
With no complaint or need for special help
Beyond an informal chat we had about what she might have missed.

Part way through that year with me
She shared some work with her peers
And I saw her strengths revealed.

We were exploring 'Change of State'
Assessment time drew near
I posed a question—in brief it said,
How could a water molecule from a lake in China reach your house?

A choice—small groups or individually
A story in words for a child
A poetry collection—a map with words
All with illustration.

Mary chose to work alone
An illustrated map—with words.

When I looked at her work, I was quite astonished.
It was all there—the science—it was a work of art.
I asked, "How can I assess this?"
I thought, this can't be right
With literacy support each week.

Mary—I remember Mary well
She prompted me to think.

For Mary to write an extended answer to the question would have been difficult. It would have challenged her writing capacity to its limits, caused her distress and taken 'forever'. To describe what was going on in her map of the water molecule's movement, by doing what she loved, to draw, was quite within her capacity. Her annotations were not necessarily grammatically correct, her spelling had some way to go but her understanding was above my expectations of a Year 7 student. In literacy support she was focusing on improving her writing skills, until confident with these Mary worked slowly because she liked to be correct. When writing long text, her mind would remain on the 'rightness of her writing', not her science understanding. By drawing the picture, she seemed more able to order her ideas and focus her thinking before beginning to write. This resulted in a logical, detailed and accurate outcome presented as a work of art. If I had asked her to explain what she had communicated in her annotated diagram in an extended piece of writing, I doubt the outcome would have been the same.

When this activity was completed I needed to ask the question, "How can I assess this?" My previous experiences with assessment had been very contained—I was now confronted by a work of art whose very beauty called to me, but its beauty was not only as an object but an object with meaning, an object that had given Mary voice (Gadamer, 2004/1975, pp. 70-87). It was because of the aesthetic nature of the object I chose to take a risk with a simple method of assessment that did not rely on my judgment alone—one I would use often in the future, one I felt was my discovery although I really know it is shared by many. I gave ten stars to each of the groups or individuals to distribute amongst the displayed works including their own. We talked a lot about responsibility and what they might look for and then I watched them respond. I could hear the discussion, see them thinking and looking intently at the work and watch them thoughtfully adding their stars.

Mary's work received more stars than any other and when we spoke about why, the words of her peers told of their appreciation of Mary's work, much of their reasoning was very like mine—they recognised the value in both content and communication. Students acknowledged for their academic status in the year group had been unable to match Mary's response but they had learned from it and Mary's confidence had grown—it was a beautiful risk for education (Biesta, 2013/16). To map the connections between the terms of the activity and write about them was conceptually demanding. Mary's work was exceptional and the other members of the class recognised this when she came to share her work.

I was only able to introduce this public assessment because I had come to know my class well. Without this knowledge, students could be hurt, they could lose confidence because of unthoughtful peer comments or a self-realisation of the inadequacy of their work compared with others. I stressed the purpose of these public assessments as opportunities, a chance to see what their work might become and to recognise the talents of other students. I began to introduce ideas of metacognitive thought—the power that comes from critical reflection particularly of personal work.

My first explorations grew to include a wide range of other more private strategies including self-assessment, peer-assessment and teacher assessment in both formal and informal settings. I introduced open and closed sharing situations. Open came to mean sharing with the class or subset of it, closed was to share with a chosen group of students or just with me. Sometimes I offered students the choice to share their work with the class or not but on others, usually when sharing was with me only, I would ask if I could share something with the class or if they would like to do that themselves. Assessment became a time of opportunity for my students and a time of pedagogical responsibility for me but what I liked most about it was that it was largely imperceptible, quietly humming in the background, its purpose of learning about science visible in the 'good' taking place. To keep track of and monitor this background hum was difficult and I tried keeping portfolios of work and asking students to monitor their own progress—each played a significant part in students' learning of science but never quite gained the stature of summative assessment.

When I needed to write Mary's term report and arrive at a summative assessment for her knowledge and understanding of science content—at the time measured almost exclusively on her achievements in common testing given to all science classes in Year 7—it would be in the lower third. Not where I believed her less measurable place should be but the result of a more narrowly focussed summative assessment. Mary was unable to achieve capacity in Year 7 science because of the lack of synergy between the summative assessment tasks and formative tasks in place. Whilst I was concerned where the discrepancies and the misunderstanding of the different outcomes might lead to for parents and students, my greatest concern was for the erosion of trust between me, my students and their parents and the damage to the developing confidence of students—especially students like Mary.

Earl (2006, p. 3) talks of contradictory messages about the purposes of assessment and the difficulty of bringing these together to "get it right". I was one of the teachers she describes as, "part of the transition, laden down with the past, while contemplating the possibilities of the future. They know how it has always been". Hopefully a solution to the disparity will reach a satisfactory conclusion without becoming too complex and unwieldy. My experiences have not deterred me from recognising the value of formative assessment, they have strengthened my need to include formative assessment as one of the five principles supporting my primary curriculum—part of my mantra for teaching and learning science in primary schools.

The demands of externally mandated assessment of literacy and numeracy in primary schools seems to have become one of the most frequently spoken of areas by primary teachers (see Chapter 2). Since aSCuPTaS is predominantly an independent and theorised rather than practised curriculum, I am in the privileged position of being able to avoid the disturbances of summative assessment, internal or external, national or international, and focus on formative assessment. In saying this, I am not indicating my total disagreement with summative assessment for some purposes, but not for the purposes of learning about science in primary schools except on very few occasions. It is not possible in this inquiry to say more about assessment—it is an inquiry in itself.

My intention in my writing is about how responsibility for formative assessment can become shared between curriculum-writer, teachers and students. Two main purposes about assessment evolve from my writing, although they are closely connected. One is to bring opportunities for formative assessment through dialogue so that these moments become shared not isolated, giving benefit to students and teachers. The other is to plan these opportunities so students can show what they understand about science using methods beyond the traditional written words of science.

I believe that to achieve both purposes the greatest responsibility lies in the hands of teachers because the decisions to be made are pedagogical ones needing to be made in the planning phase of science units whilst keeping learning, and assessment in mind. But I believe that as curriculum-writer I too have responsibilities. I have already spoken of the freedom I have in writing aSCuPTaS that allows primary teachers to focus on formative assessment but I also believe I have more freedom than many curriculum-writers to speak of pedagogy because of the great mixture of ideas that have assumed the title of pedagogy and methods. I talk further about these in this chapter and in Chapter 4.

I ask you to treat assessment in science as a time to share gifts and learn of the possible in the company of your children using ways you know bring 'good' and no harm—leave behind the loneliness of empty classrooms where children's voices echo but only you can hear.

SHARING INDIVIDUALITY THROUGH COMMUNITY

Principle: I believe science classrooms have space for each student's individuality to be recognised and harnessed within a community of learners where understanding and horizons grow from the familiar to ones more challenging.

From the early 1990s I became aware of the drive for teachers to recognise and attend to the individuality of their students. At the same time, the idea about classrooms becoming communities of learners was gaining recognition. Initially I was sceptical of the word 'community' when introduced to it, but the ice of my history melted with time and the warmth of community flowed into my heart. The idea of individuality was much easier for me to understand as I easily recognised how much I would have benefited if more attention had been made to who I was when I was at school. Little did I realise that the notion of community would find such significance in my teaching, particularly in Years 7 and 8. Eventually, I combined both ideas into one of my principles for teaching science. I found it truthful to the needs of students, teachers and science—this required significant transformations to my beliefs of the purposes of teaching science and my understanding of science teaching.

In this section I focus on how I resolved these two ideas of community and individuality that might have resulted in resolute conflict. Conflict first arose as I began to recognise the role community might make in supporting my students to learn about science whilst there was a constant push to recognise students as individuals, each with something to contribute to the science learning taking place in our classroom. I was challenged not so much by the notion of individuality but by the ideas of how this might be achieved—many ideas seemed to dwell too long on self to the exclusion of others in a way that might lead to narcissism and isolation.

I begin with a short story of the history of differentiation in Australia as I know it.

Each one is different

Differentiation
Was not unknown in Australia
Although the books arriving

On our desks in the 1990s
Professional learning
Opportunities for workshops
Might have deceived you.

It had been here before
At a macro level
Grammar schools
The British system
Of recognising differences
Measured at eleven.

Comprehensive schools
Differentiation measured for
Allocation to a stream hard to escape
Top or bottom—A perhaps E
Or even K at some schools.

Independent schools
The ‘public schools’ of Britain
In Australia—measured—allocated on
Heritage—affluence—intelligence occasionally
Scholarships—you know
Opportunities.

Primary schools
Groups—then more groups
And even more
Testing, testing—such clever tests
That identified the slightest differences.

Individual learning—set by teachers
Individual learning—on a screen
So much teacher stress
They leave and work elsewhere.

Exclusive, categorised
Horizons collapsed

To a narrow space and place
Of self.

I found these ways exclusive, often categorising students on what they knew and could demonstrate at an age when many had not yet found, or had not had opportunities to find the possibilities of their 'being' that might be hidden within. How discouraging this visible placing into categories might be—few of us would feel good if we were placed in the 'tortoise' rather than 'rocket' group, if we were not invited to make a model because our work was never finished or if we were not called to be part of the 'gifted and talented' program. I sensed something wrong with the growing perception that to categorise and individualise would help students' chances for education and questioned the lifelong effects constant categorisation of children might bring—whether it would help students find the possibilities of their 'being'. "They arrive already labelled and categorized. English as a second language. Refugee. Autistic. Down Syndrome. Attention Deficit Disorder. Gifted. Behaviour problem" (Seidel & Jardine, 2014, p. 173). They already have their own preconceptions of who they are —unimaginative, talkative, quiet, lonely, uninterested in science—these last words sadden me, they seem to come too early (see Chapter 1).

I find primary teachers for whom I write aSCuPTaS suffer more than those in secondary schools because of the way testing, labelling and treating differently have become the accepted response to handling the different needs children have. As testing and measuring techniques have evolved to a fine art and perhaps a dangerous one, their capacity to identify multiple variations students might have in literacy and numeracy have increased. I question the purpose of so much testing and why teachers often become responsible for preparing almost individualised programs for their students.

I speak of my ideas of differentiating in this chapter to show that in science there is a way of recognising the individuality of students within a community of science learning, especially in primary schools—a way that does not lead to more busyness for teachers. As curriculum-maker, I return to my own experiences to help me be me, find the authenticity of my belief and perhaps try "to put into words, *for the first time*, something that [I have] not fully thought or communicated before" (Maclaren, 2015. p. 377).

I return to the late 1990s when I began to explore the notion of differentiating my science classes. It began when I participated in a workshop about differentiating classrooms. Later I purchased a book, *The Differentiated Classroom, Responding to the Needs of All Learners* (Tomlinson, 1999) and searched for information on the Web. My heart sank as once more I was confounded by the sheer number and complexity of ideas—I searched for patterns and tried to find ways of differentiating my teaching. To differentiate content, process, product and learning environment were Carol Ann Tomlinson's key ideas and she suggested at least twenty strategies for doing this. My concerns began to grow because as the need to differentiate became more of a demand rather than a gentle reminder. I questioned the complexity of the demands. I questioned their writer's understanding of teachers and I questioned if the demand reflects the writer's need for control. I also questioned the 'good' that might come from some of what I was reading.

But, despite my questions, I was easily drawn into conversation about the individuality of students because of the value I saw in teaching in a way more mindful and more responsive to the individuality of students. It was when the emphasis on choice increased that I began to think more deeply about why I was uneasy about what I was hearing—let students choose how they want to learn, when they want to learn and how they will present what they know. My apprehension as a teacher grew from what I saw as the creeping closure of options that might come by giving students too much choice before they understand the options available and begin to find the truth of who they are and what they contribute to the world. I refer to Gadamer, (2004/1975) and ponder the notion of horizons.

Gadamer (1975/2004, p. 304) says, "To acquire a horizon means that one learns to look beyond what is close at hand—not in order to look away from it but to see it better, within a larger whole and in truer proportion". Students' horizons have been shaped by their experiences and their opportunities as well as their genetic predispositions, some may not have had many opportunities to expand their horizons, others may have had opportunities that make them think of themselves as the labels so often attached (Seidel & Jardine, 2014, p. 173). Students are being shaped for the future—winners and losers. If given a chance to choose many find safety in the familiar, choosing within their current horizon, something they are confident of achieving—their zone of safety. I suspect we might all do this unless we are prodded internally or externally to take another step. When I hear about too much choice, I feel my purpose as a teacher being eroded because I understand my purpose and responsibility as a teacher as one of providing opportunities for students to expand their horizons—to grow, not to shut down.

I found these notions of choice might deprive children in primary and the younger years of secondary school of opportunities and this disturbed me. I call too much choice limiting because I feel it has the potential to close rather than open young students' vistas of the possibilities of science. Seidel (2014, p. 13) says, "A Curriculum for Miracles understands that life can be opened from this place called a classroom or school, or it can be closed". I wanted my science classroom to 'open' not 'close' life.

Tensions over differentiation were brewing. I found I could not imagine a means of communication sufficiently simple that the idea of differentiation in a science classroom could be expressed in aSCuPTaS, especially when Tomlinson (1999) quoted one mature teacher as saying, "This differentiation is exhausting, frustrating, and time-consuming—and I would never go back to the old way". I did not want to go back to the old way of making little recognition of the individuality of my students but neither did I want to be exhausted or frustrated.

I was beginning to understand what I did not want. I did not want to differentiate when teaching science because it might curtail students from opening their minds. I did not want to differentiate content, especially in Year 7 and 8 classes because I believed all students should have opportunities to experience this content. I did not want what I have called 'free range' learning, leaving children to be responsible for making a wide range of choices of how and what they wanted to learn—an idea that might close the opportunities for young students to develop skills, interests and abilities yet to be discovered and I did not want to lock into one method or strategy because this opposed my understanding of taking pedagogical responsibility.

I needed to extract myself from the confines of many of the ideas that were circling education in the late 1990s and think differently. I took my thinking to the "clearness committee" of Palmer (1983/93, p. 82), a place to find what matters. I found four words that mattered to me—'individuality', 'simplicity', 'sharing' and 'self-preservation'. To think in this way, would change the focus of my science classroom from one where I was the central player responsible for cultivating a mixed crop and bringing each plant to fruition, to one where I asked my students for help. For many years, I accepted the help of my students intuitively—only later was I able to make more sense of the why.

I began a more focussed journey towards differentiating within a science classroom. It involved shifting the balance from one that treated each child as the same, to one that enabled each child to bring their individuality and the wealth of their experiences to everyone in the class, not one of cultivating and possibly isolating children to their own little world of their individuality. This pooling of students' experiential and personal characteristics created a rich and stimulating classroom. I provide more details of how I put this principle into action in the next section.

As I write of what to me was a moment of enlightenment, it seems oversimplified, obvious and little different from other proposals but what I saw as I began to work in this fashion and hesitatingly evaluated through observation left me feeling that what I was doing brought 'good' for my students and was sustainable for me. The way I did this would lead to a practice of science teaching that brings many of the ideas I have talked of in this chapter to gather in a community to learn about science. Kym Maclaren writes,

> By leaving room in your classroom for conversation, you will find how much each person
> —by virtue of his or her uniqueness and difference—
> has to contribute to another's learning.
> (2015, p. 382)

IN COMMUNITY WITH SCIENCE

I reflect now on one of the first times I consciously brought the five principles I speak of into my practice of science teaching—it was in the 1990s. What I write returns me to the first lesson of a science unit when I introduced the concept of biodiversity and asked the question, why as humans we find a need to classify the life on our planet and how we do this. The students I worked with were all girls who were at the beginning of their first year in secondary school.

A Preliminary Conversation

So, what makes an elephant different from a crocodile?
Size, colour, skin, shape.
Elephants smell
Elephants poo is huge! Why?
Do crocodiles poo?

Tusks—elephants have tusks and need
Teeth, food and habitat and a place to live.
How are tusks and teeth different?
Crocodiles are cruel
Cruel—they kill for food
Is that cruel? Do we kill for food?
Is that different?
Elephants can be cruel—can they?

What about their insides?
Search the Internet.
Wow—they're almost the same as us.
Related—at least a little bit.
What about spiders?

Aunty Daisy was bitten by a spider
She almost died.

How are spiders different from insects?
Ants are insects—they bite
So do spiders—they have eight legs
Ants have six—do all insects have six legs?
I know—I know—I know
We know
A lot between us.

Pause—to make a model
Keep talking—keep listening.
Yes, you can name it.
Fred?
Perhaps we shall talk about this.

Now let's make
Insects and some spiders.

Transforming observations

No students sat with hands up waiting for help as they began making models of insects and spiders. Our preliminary conversation, albeit conversation that wandered, distracted, refocussed and began again, had filled students with confidence as they rummaged through the box of treasures for materials that would bring their vision to life. It left me a space to move amongst the class, ask questions, answer questions, discuss the progress of their models, help when necessary. Everyone was engaged—as this wonderful, motley collection of multi-coloured insects and spiders evolved.

Some finished earlier than others—they might have been more focussed, less attentive to detail or more intellectually capable or it may have been that the ones who hadn't finished had chatted too much—there was always another challenge waiting for this splinter group. I spoke briefly about the binomial system of naming—they created biological names for their mythical insects and spiders using a list of some of the commonly used descriptors. They were using their laptops, thank goodness. Laptops were newly introduced in my school, we were urged to use them each lesson.

The few who took Latin could see the source of many of the descriptors—they felt proud of this. As those still working on their models finished, a peer learning situation evolved spontaneously, so the 'slower' students, whose models were often delightfully creative and carefully constructed with great attention to detail, could also create beautiful, wondrous names—*Octus hersutus*, *Hexapoda odorus.* Often the names referred to the colours of the models they had made—it gave us an opportunity to talk, once I asked the question, of the reliability of colour and size in classification systems.

One or two students began to understand classification was something that humans imposed and that insects, spiders and other organisms were not born with a Latin name attached, this made them laugh—these ideas were ones I normally discussed in greater detail with my Year 11/12 biology class. But this was an opportunity not to be missed as an early introduction.

For those who wanted more there was always another question.

This approach was different for me. In previous years I had reversed the process, although we still made models. I would talk about the classification system, we usually watched a film, participated in some fieldwork and experimentation and wrote notes. At the end of the unit, almost as a reward, those who had finished would be able to make models. This was a more traditional approach, although there were signs my teaching was becoming more engaging and my idea of a science classroom was becoming more than a place dominated by 'lab coats and goggles', but in this previous space, there were rarely opportunities for communal dialogue, or for acknowledgement of the individuality of students. I look at the 'new story' many years later with a more focussed hermeneutic eye and with thoughts of primary teachers in my mind.

In *Transforming observations* our learning began through voice, not my voice, but the collective voice we brought to conversation. Together we knew more than enough to begin our model making—an activity that engaged students with science and would bring further opportunities for discussion that would hopefully take them beyond the safety of their current horizons about the diversity of living organisms. I had thought carefully about what I wanted them to learn and I had written exactly what I believed was the purpose of the activity. I had prepared questions to stimulate discussion, when necessary, of why we classify organisms and the sorts of differences most useful for classification. But, this activity brought more than an understanding of science principles and more than an opportunity for students to share their knowledge and understanding of science, it brought words from their personal backgrounds, particularly their ethnic, language and family backgrounds and their different experiences resulting from these.

Being in this class of 12- and 13-year-olds as they created *Hexapodus ensis* and *Villosus canus,* was a transformative moment, one when I recognised through observing and listening to my students that my previous understanding of what it means to teach was unfounded. It was the moment I realised I no longer needed to provide wisdom and knowledge to my students as the expert, filling them with my truth by depositing it as if they were empty vessels awaiting enlightenment in the way of Paulo Freire's banking model (Freire, 1989 in Maclaren, 2015, p. 374). This moment gave me a new understanding of my role. From this time onwards I often found I could share my teaching responsibility with my students—this would become a relationship to which we brought our different ideas and learned together in a rich and vibrant community.

My teaching responsibilities were lightened rather than abrogated. I remained the teacher as I planned the purpose of the activities. I chose activities I knew would be engaging for my students but because of the dialogical nature my class became, I was not the controller of the words that were said and more often I found my role was not to stop the thoughts but to listen and be prepared to carefully insert the questions. My biological background leads me to call this approach a symbiotic relationship of mutualism, where both benefit from each other. I might remain the organiser and bringer of my life experiences particularly with science—I was still the teacher—but my students had opportunities to bring their gifts to the conversation. And so, we became a community of learners.

As we continued to work as a community a sense of trust came to my science classroom. We began to know each other in a way I had never known my students before, not in a social sense, which I talk of when I connected to my students as we shared our experiences of learning about mathematics through orienteering. This was a deeper experience where students shared their personal knowledge and personal gifts with the class and allowed their peers as well as me to know them more deeply in this place of learning we called science.

I had first explored this approach to science teaching as a way of recognising the individuality of students when they worked in science so "that life [could] be opened from this place called a [science] classroom or school, or it [could] be closed" (Seidel & Jardine, 2014, p. 13). I used the combination of community and individuality because I was uncomfortable with proposals about differentiation that emphasised the provision of more opportunity for choice as a way of managing student's individual differences—something I believed might lead to isolation and exclusion. I wanted to retain the idea of opportunity without an overemphasis on choice. Rather than highlighting the individuality of each student, which often seemed to be the nature of much of the advice coming to teachers, I began to change the balance of my focus so it became less skewed towards indulging the strengths of individual students and more on the good each student could bring to the class community.

This interpretation of my reflective writing prompted me to question the ethical nature of how I was working. My questions were inspired by the work of Maclaren (2015, p. 372). Was my emphasis on dialogue going to bring anxiety? Would students become anxious in gatherings where they may be unsure of how their contributions might be perceived or by their preconceived ideas of their position in relation to other students? Maclaren (2015) was speaking about a group of prisoners, some only recently released, who participated in a university class with external students in a philosophy course she was taking.

I am questioning the ethics of my methods in Year 7 and 8 classrooms where I know from experience that similar anxieties often occur in students. As I continued working using numerous variations of this approach, an approach built around community dialogue I recognised few moments of tension or anxiety and many moments that demonstrated greater tolerance, respect and understanding of each other. I understood it was my pedagogical responsibility to tweak situations when I saw there was a possibility of apprehension or conflict and for ensuring science remained a strong focus of our dialogue. I found significant other benefits in working this way.

My observation was that nobody felt different because they were involved in alternative activities or being exposed to content that had been changed—the opportunities were equal. The non-isolating way students became involved in the learning process in a social context helped me recognise the strength and diversity the individualities of my students brought to my science classes as each was encouraged to contribute. By watching, listening and gauging students' development through various assessment techniques it became clear some students had understood more than others, but an interesting aspect was the surprising ways in which students I may not have thought strong in science contributed.

The purpose of my original exploration of community was to find a way of removing overt differentiation that might limit students' interactions with science and with the class but to remain aware of the uniqueness each student can bring to the learning of science. In my science classes I found the notion of community allowed me to be conscious of all five principles I have described. I found it achieved all I wanted without creating an unsustainable situation—so the light and energy I had for my teaching could remain burning because I "love what I do in education and this love motivates and sustains my commitment" (Whitehead, 2009, p. 94). My love of teaching had sometimes become dangerously close to being extinguished as I found my way during the rapid changes of the latter years of my career.

I believe the idea of teaching science in a community evolved from many significant transformative moments—two stand out. Recognition that my teaching role could be shared with my students and my growing understanding of the mutual 'good' that comes to classrooms if all students are invited to gather in communion. My expression of these ideas comes from my blending of words from van Manen (1990) and Palmer who wrote,

> But what scholars say now—and what good teachers have always known—is that real learning does not happen until all students are brought into relationship with the teacher, with each other, and with the subject. We cannot learn deeply and well until a community of learning is created in the classroom. (1983/93, p. xvi)

Of course, 'my way' is not the only way to teach science through community but I share ideas from this example in aSCuPTaS with a clear conscience—it is a truth, as I know it.

As I return to aSCuPTaS once more I think of other common ideas I might communicate to primary teachers about the principles and their role in bringing them to life through the science units they develop for their students. I think my words will say something like this, When creating opportunities for your students leave spaces for dialogue with your whole class, smaller groups and individual students—it has a power beyond the written word as understanding grows in the back and fro of word exchanges. Group dialogue will relieve you of some teaching responsibilities as your students make valuable contributions that come from their experiences.

Provide engaging and interesting activities that give you time to spend with individual students in need of your help. Your role is one of responsibility as you prepare the activities that give students space to learn the science in aSCuPTaS and you have opportunities to assess their progress as they work through formative assessment.

Your role is to lead and manage conversations, pose questions, alleviate disagreements and ensure everyone has a chance to participate—your role is not to stop the thoughts but to listen and carefully insert the questions.

Your role is to link the science of your activities to what is happening in other disciplines of the primary curriculum and the common skills that occur across the curriculum.

I hope this model of a teaching and learning community for science helps brings a sense of light and energy to your teaching of science in a way that is responsible to your students, to science and to yourselves.

I can see how the activity I have introduced in *A preliminary conversation* and *Transforming observations* (above) could attend to many of the notions that arise in the principles. The activity was an invitation I knew would interest this class and I believed would give each member a sense of inclusion. It gave them opportunities for formative assessment, deep learning, differentiation and the ethics of animal life. Would you kill an elephant? Would you kill a spider? Why might you be tempted? If I had been a primary teacher, I would have had more opportunities to link with the learning happening in other subjects. There are aspects of the principles and aspects of the science missing from the activity I have described, particularly the methods of science, but it must be remembered this lesson is only one of five or six on this topic I would complete with this class—more opportunities would come. But, I had found trust and truth in coming to believe that my way of teaching as a communal rather than an isolated endeavour could bring 'good' science education to both students and their teachers. Biesta writes,

> learning is basically an *individualistic* concept. It refers to what people, as individuals do—even if it is couched in such notions as collaborative or cooperative learning. This stands in stark contrast to the concept of education, which always implies a relationship: someone educating someone else and the person educating thus having a certain sense of what the purpose of his or her activities is. (2009, p. 38)

By adopting these five principles I hoped my classroom had become more one where science education took place rather than learning.

PRINCIPLES OF MUTUAL TRUST

The five principles introduced in this chapter, which became mantra-like for me, evolved from McNiff's (1988/92) ideas on action research with secondary classes, so I have not assumed they can be transferred into a primary curriculum. In this chapter I have looked at them more critically to search for their relevance to primary teachers, to my purpose in supporting the introduction of science into primary schools and to my purpose in writing aSCuPTaS. At first they might appear as copies of other principles that appear in curriculum-writing but they have become mine through the experiences I introduce in this chapter. They have become mine because I have specifically linked them to the teaching and learning of science and the idiosyncrasies this might bring—they would support students to learn about science and teachers would be able to incorporate them into their classrooms without adding unnecessary complexity to their lives. Without this attention aSCuPTaS would not be sufficiently truthful to rekindle the light of science to shine in the hearts and minds of primary teachers and the flow of energy I hope to give through aSCuPTaS would be snuffed (Whitehead, 2008).

The principles evolved from many sources, too many for me to recognise or even remember as I have been writing. I apologise for this lack of recognition but my writing becomes more authentic because of this. My way of acting was influenced by educational researchers and philosophers, authors of books and curricula, teachers and my students and from chance encounters I had with professional learning opportunities. These encounters sparked trains of thought about education, its purpose and value in our society and the implications of these ideas for schools and their members—students, teachers and school leaders. The messages that filtered through to individual teachers had undergone significant translation as they passed through education departments, particularly from those who write curricula and authors who write texts and books for use in schools. This chain of events might stop when it reaches schools but often there will be further interpretation by the leaders of a school before it reaches individual teachers.

The messages that arrived often appeared to have strayed and blurred from the intentions of the original, so blurred at times they were hard to decipher the original. In this chapter I have written of my interpretations of the messages and how these led to the five principles that came to underpin my teaching practice. As I have written about them it has become clearer they are as applicable to primary teachers as they were to me as a secondary teacher. They are principles that relate to the roles and responsibilities we have as teachers and how these responsibilities translate into the opportunities we provide to our students. I turn to Biesta's words to find support for my writing of aSCuPTaS based on these principles.

Biesta (2009) writes about ideas that need to be considered in curriculum-writing—qualification, socialisation and subjectification. In a primary science context, I translate his words to mean more to me as curriculum-writer. The idea of the qualification implies a curriculum that promotes opportunities for children to develop their knowledge, skills and understanding of, in my case, science and often also the dispositions or nature of science and forms of judgement or methods of science that allow it to be understood. The socialisation function implies that a curriculum provides opportunities for students to become members of a social group, in the case of primary science education they need opportunities to work together and begin to learn what this means to the way they behave in a social group but also to come to recognise the benefits this can bring and to recognise the individuality of the members of the group. The idea of subjectification Biesta (2009) sees as the opposite of the socialisation function. For me, this meant providing individuals the opportunity to recognise their individuality and have opportunities for expressing this. I believe the synergy of the five principles brings attention to each of these ideas. But whether these ideas become expressed in classroom practice is dependent on two people taking responsibility, the teacher and the curriculum-writer.

Biesta (2012) speaks of giving teaching back to teachers and in the article *The Role of Beliefs in Teacher Agency* (Biesta, Priestley & Robinson, 2015) introduces the idea of how much agency teachers can take for education. It is with this balance in mind that I have distributed responsibility for the principles on which I based my teaching practice between teachers and curriculum-writer. I have based my judgements on my belief of who has the greater capacity to make the decisions. It is another risk I have taken in writing aSCuPTaS. How responsible I have been in making these decisions might become more apparent in Chapter 5.

MEMORANDUM — WHAT I TAKE WITH ME

I leave this chapter with positive thoughts—perhaps they come from memories revisited, memories of working with students in ways that were new, allowing me to step away from more conventional boundaries experienced early in my career and in my own schooling.

Some of these experiences came from Year 7 and 8 classes where there was time to dwell on science without the driving presence of time and future present in older classes. With my Year 7 and 8 classes I sensed I was more like the primary teacher I perhaps should have been. Some of my experience came from working with older students, particularly those who were not traditionally 'clever' —to teach them brought substantial rewards. Their view of education seemed more aligned with John Dewey's thinking on education which seems to have become a neatly packaged quote, "education is a social process; education is growth; education is not preparation for life but is life itself" that may have originated from *My Pedagogic Creed* (1897). These students could immerse themselves in activities, admittedly designed to capture their attention, in a way their intellectually capable peers could not—for many of these students their interest in learning was distracted by and controlled by what they wanted from life. This sometimes resulted in anxiety and pressure, particularly when lives did not proceed as planned, where education had become preparation for life in a narrow sense.

This chapter has been one where I have had the luxury of thinking how the principles I describe became such an important part of my teaching life and how I found myself confidently able to defend decisions I made because I had watched them work magic. By writing I have revealed decisions I made, some of which may have been more wrong than right—this has emphasised the notion of the constantly changing nature of teaching as ideas change to meet the needs of students at the time. But it has also raised the spectre of the influences and changes that come not from the needs of students and values of their teachers but from sources both within and outside educational environments which have little to do with education in the way of Dewey or Biesta. These reflections leave me more aware of why, as curriculum-writer, I have needed to redistribute responsibility for the essence of the principles between me and the primary teachers for whom I write. Without this step, I believe primary teachers might feel little incentive to invite the teaching of science to be part of their practice.

Behind the principles that came to be my living theory of teaching, I have many people to thank for providing germs of ideas that my own grew from in the cycling ways of living theories that grow from the 'I' of living contradictions (Whitehead, 1989). Many I have already acknowledged in the words I write in this chapter but I would particularly like to thank Lois Hetland. Somewhere in the past, I received a page of beautiful ideas that told how to change an activity into a performance of understanding, a name that emerged from Teaching for Understanding (www.pz.harvard.edu/projects)—I have not been able to locate a copy of these ideas but finish with some words she wrote in 1998. Her words help me understand why my principles became important to me—they helped me know where I was travelling. Hetland writes about "Understanding Goals", a term I have used in aSCuPTaS.

> I knew I was aiming for understanding and not coverage. They helped me to use "teachable moments" toward purposeful ends, which aided me in personalizing my teaching toward individual needs. They helped me design instruction so that students would be more likely to confront misconceptions and

move toward richer webs of knowledge that they could employ flexibly in novel situations. Finally, they helped me explain and share the authority and responsibility for learning with my students, with their parents, with apprentice teachers, and with my colleagues. Understanding Goals gave us all a sense of shared purposefulness that allowed us individual freedom to explore. (1996, p. 8)

CHAPTER 4

COMPOSER, CONDUCTOR AND ORCHESTRA

I begin this chapter by reminding myself of the purpose of this inquiry, which sometimes becomes lost in the activity of my words.

To kindle the light

It has become hard for some
To kindle the light of science to burn
In their hearts and minds
And those of the children they teach.

But the hurdles of their resistance
Can be lowered if we—the curriculum-writers
Bring down the barriers
By thinking of who they are
And what they might need
To bring opportunities to their students
With the energy of potential
Stored in brains of different
Capacities and gifts.

These words speak of the overall purpose of my inquiry and are written for primary teachers and their students from the mouth of a curriculum-writer who believes a curriculum written for primary teachers may help remove some of the barriers of resistance or at least reduce the energy required to overcome them. In Chapter 3 I distribute responsibility for the five principles of my living theory of teaching between curriculum-writer and primary teachers and blithely say, I leave ‘this’ in the hands of primary teachers and I will take responsibility for ‘that’ as curriculum-writer. I believe sharing responsibility is a critical consideration if aSCuPTaS is to achieve its purpose.

In this chapter I focus on what it is I am expecting primary teachers to do and why I am comfortable with this idea, and to bring greater truth to my belief that pedagogical responsibility for science teaching in primary schools is best remaining in the hands of generalist primary teachers. I trust generalist primary teachers have the capability and intellectual capacity to take responsibility not only for teaching science but for writing their own science units and believe their teaching has the potential to breathe life into science in ways that might not be realised easily by others. But my trust in them has the potential for increasing the barriers they see in teaching science and I must remain mindful of what is required from me as curriculum-writer. I introduce ideas about pedagogy, responsibility, balance, motivation, communication and trust as the text of this chapter moves thoughts in this way and that.

aSCuPTaS evolved from my heart of trust in handing much responsibility for science teaching to generalist primary teachers, but I know my trust does not easily transfer to those who express doubts for this possibility—doubts fuelled by concerns for science teaching in Australia’s primary schools that have continued despite many attempts to remediate the problem over many years (Fitzgerald & Smith, 2016, pp. 65-66). I speak of these ideas in Chapter 2 and must “remember that the change [I] aim for may have different significance for different people” (van Manen, 1990, p. 7). As curriculum-writer, I find myself the pivot between two doubts—those who have little trust in the capability of primary teachers to teach science and the doubt of primary teachers who might not trust themselves to teach science.

For this reason, I explore more deeply the basis of my trust and the source of the doubts that have been voiced and the tensions these might cause for primary teachers. My hope in aSCuPTaS is that it will support primary teachers to develop a renewed sense of self-efficacy (Bandura, 1977) and belief in their capacity to teach science that might bring new life and perspectives to science teaching in primary schools, so they can kindle the light of science in the hearts and minds of their students.

In the latter part of this chapter I re-evaluate my responsibilities as curriculum-maker to make contributions to the pedagogy and methods of science teaching through a curriculum and ask what can be written and what can be said in a curriculum. I talk of the delicate balance between freedom for teachers and what I want to say because of my beliefs of the nature of a ‘good’ education and a ‘good’ science education (Biesta, 2009, 2012). I also explore why I have assumed responsibility for guiding primary teachers to spaces of possibilities to enrich the science experiences for them and their students. Each exploration of narratives that come from my heart leaves me with a greater sense of certainty that my instinctive trust in primary teachers is not unfounded—it has grown from and is supported by my ‘lived experience’ and understanding of how my trust might bring ‘good’ to the teaching of primary science and supports my purpose for teaching science in primary schools.

As this chapter progresses, I see once more the intersecting, fluid and commutable roles of teachers, students and curriculum-maker, and how these come together in the way of an orchestra—aSCuPTaS becoming the manuscript that takes my message of science to the conductor and his/her her orchestra. I ask, is it a message penned with pedagogical tact (van Manen, 1990, 1991), a message that speaks truth to primary teachers and their students, and is it a message that might bestow freedom and opportunities to explore the science that surrounds them? Much of this chapter is about pedagogy, not the details of activities, methods and techniques but about pedagogy as responsibility and an art of teaching.

I begin by visiting the term ‘pedagogy’ and how I have grown to understand it. The word came from one used to describe a young Greek boy’s tutor, a pedagogue, who would take responsibility for his upbringing and introduce him to cultural practices. This role differed from that of a *didaskalos* (teacher), who worked with older students, both males and females and educated them for their adult roles. Since then the terms ‘pedagogy’ and ‘didactics’ have undergone many interpretations (Hamilton, 1999). In my writing, I differentiate them in the way more commonly used in Anglo-American areas, including Australia.

Hamilton (1999) cites Peter McLaren’s (1998) description of pedagogy as

> the integration in practice of particular curriculum content and design, classroom strategies and techniques and evaluation, purpose and methods. All these aspects of educational practice come together in the realities of what happens in classrooms. (In Hamilton, 1999, p. 148)

During the 1990s and first decade of this century when I was teaching, pedagogy seemed to become synonymous with the activities and techniques that could be used to engage students with learning and provide opportunities for dialogue between teachers and students. As Biesta (2012) points out, activity, without a purpose and vision for what students might be engaging with and conversing about may not be educational. Even though only a small portion of McLaren's definition of pedagogy was being attended to in the latter years of my teaching, in comparison to the didactics of my experiences in a 1960s high school and the way of my career in the early years of my teaching, schools seemed to have become more interesting. Hamilton (1999, p. 142) writes of Wolfgang Ratke (1571– 1635),

> Ratke' s didactics projected an active view of instruction (or telling) and, as a result a passive view of learning: 'All work falls to the teacher', he concluded, leaving young learners to 'sit still, listen and be silent. (as cited in Michel, 1978, p. 65; Comenius, 1953, p. 107; Turnbull, 1993, p. 391)

Hamilton adds, "Freire rejects this as a dullness-and-dogma view of education where 'the teacher talks and the student listens – meekly'" (Freire, 1971, as cited in Hamilton, 1999, p. 146).

I believe McLaren's pedagogy (in Hamilton, 1999, p. 148) describes the more idealistic role I aspired to when teaching science in the latter years of my career. I came to understand my role as one of pedagogic responsibility that relied on my competency to make decisions appropriate to the needs of my students and the underlying principles and content of the curriculum. In other words, I came to accentuate pedagogical responsibility, giving me greater autonomy to make responsible decisions about the methods I might use to bring 'good' to my students. It is this idea of a pedagogy of responsibility, attentive to the individual needs of students and one where teachers take responsibility for the child/student beyond the arena of science understanding to include a focus on social development and introduce him/her to cultural practices, I hope appears through the words of aSCuPTaS.

I find some difficulty with the idea that if teachers have access to the individual components that constitute McLaren's 1998 definition of pedagogy (as cited in Hamilton, 1999, p. 148) then they can bring these notions together in practice with a sense of responsibility. I wonder if there is something elusive at the source of this ability and ask whether all teachers have this capacity and what it is about primary teachers that creates a sense of pedagogic responsibility I believe many of their secondary colleagues find difficult.

It is the idea of pedagogical responsibility that fills the following pages—not only the pedagogic responsibilities of the teacher conducting the orchestra of the classroom but also the responsibilities of the producer of the manuscript. First I look at the gifts of the conductor that support my trust the manuscript of aSCuPTaS can come to life in his/her hands.

A PRIMARY GIFT OF SCIENCE

The path I travelled to change my vision of secondary science teaching, and revisit in Chapter 2, was perhaps one less travelled and possibly more troubled than it might have been. Dewey in *Experience and Education* says,

> After the artificial and complex is once institutionally established and ingrained in custom and routine, it is easier to walk in the paths that have been beaten than it is, after taking a new point of view, to work out what is practically involved in the new point of view. (1938, p. 11)

I hope aSCuPTaS helps make the change to custom and routine easier for primary teachers because my act of writing aSCuPTaS recognises my support for a change to what many primary teachers often believe is their principal academic role—taking responsibility for the development of their students' literacy and numeracy skills (Donnelly & Wiltshire, 2014, p. 3). They may prefer not to explore what is involved in the 'new'. The new is not the introduction of science—science has had a place in Australia's primary schools for a long time. The new is my strong belief that responsibility for teaching science should be in the hands of generalist primary teachers—it is a belief that might not fit comfortably in the hearts of primary teachers or those who find it difficult to trust this possibility. The possibility comes from the trust I place in the woven patterns of aSCuPTaS that come from spindles of yarn emerging from my 'lived experiences'. Unless I trust the primary teachers I leave to bring aSCuPTaS to life, it will remain dormant, in the same way it might if primary teachers do not come to trust in their capacity to teach science. I call upon several experiences to help me understand the source of my belief that 'good' might come from the chemistry that happens between aSCuPTaS and generalist primary teachers.

I begin by looking more closely at what it was that inhibited my progress to take pedagogical responsibility for the students I cared for in the way that had become my living theory (Meyer, 2008; Whitehead, 1985, 1989, 2008) of science education. I look particularly at the practical and emotional barriers that impeded me from fully resolving the contradictions to my living theory of science teaching based on the five principles I introduced in Chapter 3. Some of the tensions that inhibited my teaching of Year 7 and 8 science classes in the way I wished came from the physical organisation of secondary schools and the way they operate. Others were of a more emotional nature that grew from a working environment where there were undercurrents of conflict and purpose. I have written of these ideas in *I began to talk of 'we'* (my page 33). Before I continue, I write a short narrative,

A space to call my own

I longed for a space to call my own
For walls where work
Could be displayed with pride
In their achievement.

For space to keep those
Works in progress
With just a little more to add
More glue, more coloured scraps of fragile gems
Found in fields of excursion.

Not rooms shared with many teachers
Scores of students—shifting furniture and
Beautiful, precious work lying broken, torn
Suspended by a single pin.

I longed for soundless flows of time
Seamlessly crossing boundaries of bells
When necessary—not marking pace in unrelenting blocks
Stop, move on and start again
Another room, another class of
Faces—for a short time
Again and again and again it started
In just one day.

No easy place for connections
Remember—we spoke of Copernicus last week
And wrote Haiku about his imaginations of
Heliocentric solar systems.
Could you write one now to say how it feels
To hold the exquisite movement of a
Millipede in the palm of your hand
And watch the white breasted sea-eagle
Circle overhead?

No easy place to know your students
To know why Thomas had tears in his eyes
To know why Amy abandoned Anna
To sit beside another—why Sammi struggles with his words
To know that Sarah and Samson have a prize
For their violin playing in duet—please play for us now
We'd like to hear music of moons and millipedes.

To know, to know, to know
How hard to know one hundred and twenty students
Or maybe more each week that passes in
Solitary, single, segments of time.

How priceless are these 'knowings'
When teaching.

The drift of my words reflects my changing perception of science teaching from one that promoted the knowledge and methods of science, to one of invitation to and inclusion of all students into a world of science.

The inclusive and inviting nature of my teaching required spaces for communication, community, the arts, technology and to know my students. To acknowledge my students' responses to the invitations I offered to become involved in learning science called for displays, respect for each individual's work and flexibility—needs I found difficult in the physical and operational environment of secondary schools and have voiced in *A space to call my own*. My pleas seem trivial now as I write in the luxury of time and space, but loomed large then, when the smallest of things could easily stall my good intentions. The invitations I wanted to send to my students to join the circle of science were not easily sustained within the constraints of a secondary school's organisation—my energy to practise the values of my living theory were often insufficient. My writing is a gentle reminder to me as a curriculum-writer that the slightest of impediments can easily extinguish the quivering candle of change.

From my writing in Chapter 2 and my interactions with Australian primary teachers, I believe it is fair to say most do not have the difficulties of having no space of their own. They have a classroom where they focus on literacy and numeracy, work can be displayed, work in progress can be stored and teachers can come to know and understand their students. Their classrooms are the space of safety I longed for—a space of advantage when teaching science truthful to the values of the five principles I write. Spaces that make me believe the contradictions I speak of in the way of Whitehead (1989) might often be absent in their schools, although I sense this might change if we are not careful.

Another impediment for me was an emotional one that came from living with critical undercurrents that cast doubts on my belief that the purpose of teaching science in early secondary years and the teaching methods should change—doubts that might have been slight niggles, but ones that were enough to slowly erode my confidence. I believe this notion of doubt may already have placed negative pressure on primary teachers as they teach science and augmented their lack of belief in their capacity to teach science. I believe their doubts may have come from both the teaching and general community's and primary teachers' own perceptions of what it means to teach science.

A GROWING SENSE OF DOUBT

In Chapter 2, I have spoken of how primary teachers may lose their courage to teach science because of their perceptions of what it means to teach science. I believe these perceptions have come from those who find fault in their lack of science background and have a different purpose from me when we speak of primary science. I add some more ideas as I write this chapter, ideas that relate to more general conceptions of primary teachers that might have worn down their confidence to teach, especially to teach science. To uncover further truth in my assertion that doubt reduces confidence, I retrieve a number of memories and ask questions about self-efficacy. What do these experiences reveal that might bring primary teachers to doubt their self-efficacy to teach science? I have used the term 'self-efficacy' several times, but write a little more before I continue. Albert Bandura (1977) found support for his hypothesis "that expectations of personal efficacy determine whether coping behaviour will be initiated, how much effort will be expended, and how long it will be sustained in the face of obstacles and aversive experience" (p. 191).

My focus is on retrieving many primary teachers' low expectations of their ability to teach science. This reflective practice helps me bring more authenticity to my developing theory as a curriculum-maker, that if primary teachers receive the right support, some of which might come from a curriculum such as aSCuPTaS, they could bring pedagogical gifts to primary science teaching that add an energy of 'goodness' to their students, who in turn might carry this energy to their secondary schooling and their lives. I use 'good' in the sense of van Manen (1982, 1990) and transcribe my understanding to words of my own as curriculum-writer. In this role I hope to speak with pedagogical thoughtfulness to primary teachers of our responsibilities, mine to the teachers so they learn to recognise the important contributions they make, and their responsibility to the children we love so these children come to understand and respect the science in their lives and act responsibly towards what they have come to know through its learning. Van Manen writes

> the pedagogic good is not a goal of education which is itself a
> means to another end. Rather the pedagogic good is the end, the

> end in itself, from which all our hope, love, and inspiration for our children draws its meaning. (1982, p. 47)

I continue this trail of exploration of the sources of doubt primary teachers might have in their capacity to teach science by returning to times when my interest in primary teaching was questioned and my secondary colleagues began to speak of me as a primary teacher—at first I saw this as a slur but came to recognise it as a compliment.

No room for pedagogy

Not primary teaching—no, not for you
Not teachers' college—as it was then
Science—a degree
Much better—you do enjoy biology
The message from my mother.

Care of the individual
Pedagogy—for primary teachers perhaps
It is the kindergarten way
The message from my colleagues.

I began to know my students
I began to do things that would take their interest
I found teaching more interesting
It gave me more responsibility
Art, music, stories
The message from me.

'You should have been a primary teacher'
No room—no time
For the nonsense of pedagogy
In secondary schools.

A breakfast meeting to share
My new 'curriculum' Year 7 and 8 science
Where is the science they ask?
Where is the science in my curriculum

Of pedagogy—my curriculum
That had come so readily to me.

Science needed no words for me
Science knows me and I know science
We have been friends for many years.

I remind myself of a recent friend—pedagogy
That found my hand—took hold of me
Allowed me to become a little bit
Like a primary teacher and know my students.

My state had moved from boundaries iced
To ones that flowed and merged
With lights and sounds from other souls
And I am proud
But ask why me?

My historically lived personal experiences evident in this writing reveal feelings of disrespect for primary teachers—of what they do and who they are—that has continued over many years both in the general community and the academic arena. I am not sure when it began but I believe there was community respect for teachers in my primary school days of the 1950s and 1960s in both Australia and the United Kingdom, for the schooldays of my children and for the earlier part of my teaching career—now I find significantly less respect. It is beyond the purpose of my inquiry to pursue these ideas except to say I believe it has become exaggerated since the results of national and international testing programs, their media exposure has increased and the values of measures have changed.

I sense something flawed in these judgements of primary teachers, my mother's implications, the dismissive response of secondary teachers to the word 'pedagogy', their appellation of 'primary teacher', their instant reaction to the lack of content in my first attempt at writing a curriculum and their lack of recognition that words of pedagogy may have something to say to them. I feel this more acutely now I have become a little bit like a primary teacher and understand more the powerful role primary teachers might play in science teaching. It is this developing pride of belonging to and being thought of as part of a primary teaching culture that urges me like Palmer to persist with the

> 'who' question because it marks a seldom-taken trail in the quest for educational reform, a trail towards the inner resources that good teaching always requires. Real reform is so badly needed — and we have restructured education so often without reaching that distant dream — that we should be sending expeditionary parties down every trail we can. (1998/2007, A Seldom-Taken Trail)

I do not doubt primary teachers' confidence to teach science has been abraded, but begin to wonder about the source of 'inner resources' that primary teachers might have that seem to elude the understanding of some secondary teachers. I believe many advantages might flow to secondary science education if there is greater acceptance of the different purposes of science in primary and secondary schools. If the purpose of primary science teaching is changed to the one I speak of in previous chapters, then I believe the best resources are already in our primary schools, our "wonderful primary teachers" (Crook & Wilson, 2015).

In writing aSCuPTaS I hope I have compensated for three of the most commonly expressed concerns about primary teachers' capability for science teaching—their lack of science background, science knowledge and pedagogical content knowledge (PCK). Lee S. Shulman describes PCK as "the most powerful analogies, illustrations, examples, explanations, and demonstrations—in a word, the ways of representing and formulating the subject that makes it comprehensible for others" (1976, p. 9). To do this seems to remain foremost in the hearts of many secondary science teachers, as it did in mine when I taught Year 11/12 biology. I have little doubt that for helping students to understand the subject, PCK is invaluable and is central to Australia's examination systems for tertiary entrance—I am not sure my purpose of teaching science in primary schools calls for this sort of rigour.

I began to look for the signs of inner resources that might make 'good' primary science teachers from those who have already chosen to teach.

TEACHING AS AN ART

I believe the life generalist primary teachers might bring to aSCuPTaS is not determined by the content I have included in aSCuPTaS, but from the idea of teaching as a science becoming recognised as teaching as an art. I wonder if teaching is an art engraved in the hearts and minds of many primary teachers in a holistic, human way of nurture, that could be a gift to primary science education —this idea rests easily with my purpose for teaching science in primary schools. Perhaps this gift might be the 'inner resources' of a 'good' teacher in Palmer's 1998/2007 words above or those from Donald Schon who

> describes this new epistemology of practice in the following way: one that would stand the question of professional knowledge on its head by taking as its point of departure the competence and artistry already embedded in skilful practice. (as cited in Murphy, 2008, p. 34)

It is this competence and artistry that might be embedded in the skilful practice of primary teachers that I trust. Biesta also writes of pedagogy, "In this way teaching can, and in my view should, thus be understood as a *gift*" (2012, p. 41). As I have come to understand primary teachers more deeply I believe many have been attracted to teaching because they possess a gift for interacting with younger students. I am talking of primary teachers' general pedagogical skills, rather than those peculiar to science. I am more interested in these general teaching skills because of the purpose I bring to science teaching in primary schools—to kindle the light of science to burn in the hearts and minds of primary students. This purpose helps shift the focus of primary science from the content and methods of science to attitude to and engagement with science.

Van Manen (1990) writes of pedagogic competence in words acknowledged to have grown from Martinus Langeveld (1965), "the anticipatory and reflective capacity of fostering, shaping and guiding the child's emancipatory growth into adulthood" (p. 159). I believe primary teachers have the capacities of pedagogical competence and ponder the links between pedagogical competence, inner resources and gifts or perhaps they are one and the same. I continue with another reflection on who I am and what might have been the source of my interest in primary teaching.

Jack of all Trades

Barbara—again
We have concerns my parents say
Jack of all—master of none.
Not quite right let's think again
Quite good at everything
But not a thing stands out.

A bit of this a bit of that
Some art and music, maths and science
English let's not be so brave
The words just fail to come on cue
Languages mm … let's leave them out
Memory is the handicap.

Imaginative—creative—yes
Thinks—explores—yes—yes
There's quite a lot
But nothing quite stands out.

But now I know I have a place
I could have been a primary teacher
I wish I had—sometimes.

Now I am an artist—linked to
Lines and landforms of the natural world
Where plants and animals find their space.

Thanks to my mother—you got it right
About biology—not what it brings
So much as where it takes me to
And ponder what it is and how it feels.

My story's truth is who I am
My mother cast in critical light
Not quite so black and white in life
A clever brain that never found a chance
To reach capacity in times of war

In times of hurt—in times of larger families
When siblings took the place of fathers
Gone or sometimes lost.

She spoke to give her children
Chances she had never had
Not losing sight of what
It might have been for her.

My brother filled her eyes with pride
Until the poignant day he died
A day when tears took their place
Beside her eyes of pride.

My dad and I would watch the birds
Our voices rarely spoke or heard
Our minds on inner thoughts
And plans—we were the Jacks
He was—I am
I understand.

Jack of all Trades begins to reveal my nature and I wonder if this 'Jack of all trades' temperament and creative disposition allowed me to be attracted to ideas of teaching science in a way beyond the canonical white coats, goggles and written reports—an escape from the way I had been taught. My mind was open and easily tempted by the idea of a more creative science classroom and becoming responsible for making choices about what I might do to attract students to interact with and come to understand science. It suited me perfectly to fiddle in a space of insect making, Latin names, drawing, writing, imagining, before brief returns to more traditional ways of learning science. I believe my mind may be more like that of many primary teachers—generalist primary teachers who may show no specific aptitude except to the art needed to teach primary children.

Few of my science colleagues shared my interest or understanding of the need to invite more students to engage with science including those amongst my colleagues with a special disposition for science who tried to groom their students in their own image (Tytler, 2007, p.57). What happened in my Year 7 and 8 science classes as I made these invitations was relatively invisible, but in the integrated area of Parallel Studies I speak of in Chapter 3, little privacy was available. Colleagues from various persuasions came to supervise this integrated program, because this was the way it was managed—I believe many were uncomfortable with the 'play' they saw.

The uneasiness of 'play'

I watched as they picked their way among the debris
Suspicious eyes cast over beautiful boxes
Made to house memories.

They watched a young girl's lament
Of the death of her grandmother
Emerging as creative dance
And the melancholy of music.

They read a journal from the pen of a student
Sharing a walk with her family
In the misty wilds of a national park
Where winds wailed before the coming of the sun.

Some of the trespassers could not understand the purpose
Of an integrated subject or if they understood the purpose
They could not understand the process.

Others felt an undermining of the purity of their
Specialised area—especially some from the arts
Many could not understand the process as an invitation
To commune with values.

The reaction of some who came to supervise I found quite disturbing. It was not only those from the science and mathematics areas who brought this narrow view of what counts as teaching as I might have imagined, they also came from other faculties. These observations raise the idea of subject as focus again, especially amongst those who taught only Years 10-12 and whose ideas seem to drift down to younger age groups.

This rejection or lack of recognition of the worth of what these students were doing may have come from uncertainty of how they might contribute, but Palmer suggests another reason.

> If students and subject accounted for all the complexities of teaching, our standard ways of coping would do — keep up with our fields as best as we can and learn enough techniques that keep us ahead of the student psyche. But there is another reason for these complexities: we teach who we are. (1998/2007, We Teach Who We Are)

Perhaps I was realising who I am and being more truthful to my heart, because I knew how much I would have enjoyed having had the opportunities my Year 7 and 8 students were having in science and Parallel Studies. Was this being selfish and narcissistic? Palmer says no, and stresses what I begin to understand, the necessity for teachers to know who they are if we are to "serve our students and our scholarship well. Good teaching requires self-knowledge" (1998/2007, Landscapes Inner and Outer. This understanding helps me become both more tolerant and less tolerant I try to explain.

My text of *Jack of all trades* resumes an idea hinted at in *No room for pedagogy*—one that happens when a pedagogue tries to recreate someone in their own image, someone like they are or would like to have been, without understanding that the person they educate needs opportunities to become who they are themselves (van Manen, 1990, pp. 159-160). It is a point relevant for all teachers but begins to help me see how it supports my idea that primary teachers have characteristics I want to harvest for teaching science. They have not chosen to go into careers requiring a specialist field and many have chosen to work with children because they care for them—most universities use words of the type, 'prospective students should enjoy the challenge of supporting their children to reach their capacity' in their invitations into primary teaching courses.

I believe I share these generalist characteristics with many of my primary colleagues and begin to think and talk of 'we' again from my position as curriculum-writer speaking to teachers. I wonder at the advantages our open minds, often disconnected to the more focussed minds of those who specialised in science or English or history, might bring to science teaching in primary schools. With these minds, I believe primary teachers might create invitations to science through their imagining of a wide range of opportunities for students to grow and understand their relationship with science in primary school. I begin to see these minds might issue invitations to English, mathematics, history, geography, the arts, physical and health education and matters of value and ethics. This makes me think what I have missed by not being a primary teacher. This thinking raises more ideas about teacher selection and training—I speak of these in my final chapter and return to matters of primary teachers and science.

It is because of the 'Jack of all trades' mind and the pedagogical competence, inner resources and gifts that many primary teachers seem to have, that I suggest they are encouraged to take responsibility for teaching science in primary schools —together they might bring qualities of 'good' to science teaching because of who they are. My thoughts are brewing ideas about how the minds of secondary science teachers might be transformed, but for now I return my 'Jack of all trades' mind to the process in hand—curriculum-making.

IN THE MIND OF CURRICULUM-MAKER

Unfortunately, teachers in Australia and other parts of the world are already suffering because of the changing nature of their responsibilities. Seidel says,

> We are distracted by pressures of accountability, by the way things are supposed to be done, by intense demands for certain kinds of performance — all linked to the 'future' and distanced from our present urgencies and relationships. No wonder we feel exhausted. The intense pressures of our future fantasies and longings erase the layers and layers of life that hold us up, distracting us from our ability to stay here now. (Seidel & Jardine, 2014, p. 145).

Perhaps I contribute to their exhaustion by my support for science teaching in primary schools but hope my contribution comes gently because as curriculum-writer, I understand the need to share—accepting my role as provider of the science of the curriculum leaving the important 'stuff' of pedagogy in primary teachers' hands because they know when to stop, what to leave out and what to attend to first. They know Johnny's dad might come looking for him at school despite a restraining order, they know Daisy draws beautifully and Charlie from

Turkey arrived from a refugee camp last week—my teacher did not know I had just come from England, that I did not know about dusting duties or how to knit, she did not think that nearly sixty years later I would still feel the shock of the ruler on my leg—there was no pause. Primary teachers now might know when to pause—let's take a break, walk to the river, make some boats—they may even say some sink, some float. I believe generalist primary teachers have the capacity to teach science if accompanied by something such as aSCuPTaS and their sense of pedagogical competency. aSCuPTaS alone cannot ensure children will learn to appreciate science—it can only happen with the guidance and love of their teachers.

A teacher's yesterday

Yesterday was the first day of school
Shining faces—washed and free of sand
From beaches of summer
To new shoes and shirts of school.

Ethan came for his first day at *big* school
With twenty four others and some tears
For the new of turning six.

A picture board amidst the tears
Photos, drawings a few words of who you are
A dog called Jackson, Mog the cat
Cows and tractors—we are in rural space.

Settled now—eat lunch, run out and play
Outside where the big children are
To explore until the first screams, the running, the shouts
People moved from inside out and outside in.

Frightened children crying, huddled with their teachers
Speaking of wasps who had gone wild when disturbed
Ethan's tears washed the stings from nine wasps
On his first day at *big* school
Too many stings to watch until the sirens sounded.

The officers came and calmed them down
Except for Ethan who was beside himself
And went away in the ambulance, his red shirt stained with tears
On his very first day at *big* school.

He Is back today—his teacher makes a fuss
Ethan speaks to the class—about his experiences
Sometimes he jumps up and runs away
The wasps are in my shorts he shouts again and again and again ...
It might take time for Ethan to feel safe at *big* school
But he has the help of his teacher.

There is another drama now—a father wants his children back
So sad in schools where children go to learn
About science and many other things.

I wonder at my audacity in asking more of primary teachers and whether I have forsaken my responsibility as curriculum-writer. I find myself in the middle of another conundrum not dissimilar to the one I talk of in Chapter 2, which revolved around my changing views of the purpose of science teaching in primary schools. I focus now on the gifts primary teachers might bring to help achieve this purpose because they are here amongst us, not in some future of science specialists who may remain mostly in the dreams of some for many years to come, but perhaps I ask too much.

It is clear I have some concerns about directions being suggested for primary science and want to retain generalist teachers with 'Jack of all trades' minds in primary schools because they bring opportunities to make cross-curricular connections, to remain attentive to the development of skills taking place in other areas of the curriculum and incorporate them as they teach science, and to attend to the individual needs of the students they know. There are also opportunities for class teachers to redistribute time when necessary without significant negotiation and opportunities for observing and monitoring their students' development from a holistic viewpoint. These are some of the reasons for my preference, my dream for science to remain in the hands of generalist primary teachers, but the greatest advantage is that class teachers are in a unique position for designing units of work in science that cater for the individualities of their students that are possible in the schools and the environments where they teach.

If I ask generalist primary teachers to write their own science programs I need to show I trust them with this responsibility. My continuing search for why I strongly believe primary teachers have the capacity to take this responsibility diverts me to explore the notion of motivation. I begin with more words from my teaching career. Words that trace my teaching heart—for many years there was little in my heart for teaching.

Bringing a heart

Motivation to teach—altruistic?
Perhaps at first but soon to become
A desire for an income
A heart kept well-hidden as
Boredom kept creeping—motivation seeping
Naughty boys, disinterested girls
A challenge to discipline
Few responsibilities for teaching
Was this a career in teaching?

Biology came with a glimmer of light
Students who wanted to learn—for marks on exams
Strong purpose, strong reason to work hard to achieve.
But the act of teaching was not quite so demanding
Blackboards and teacher-talk, occasional films
Questions and answers—diagrams, long explanations
To help move them along to their goal of achievement
Shulman (1986) would be proud of my PCK
For my subject.

A few, very few showed less inclination
And less motivation—I thought I would try
This art of teaching I was hearing.
Butcher's paper, coloured pens, wiggly lines that connected
Words found in books—words that we spoke
As we sorted it out together

Something happened to them
Something happened to me
We hadn't expected.

I got a letter that year—from the principal
Not about the success of the high flyers in the usual way
Who got where they got—without much help from me.
It was this small 'group of four' who surprised us
By passing the test they might have failed
My motivation to teach soared.

I had a new purpose—to plan for classes
To plan for each student and their special ways
I was a teacher and took responsibility
I was in charge and found a place for my teaching heart.

In *Bringing a heart*, I speak of my lack of motivation when I started secondary teaching because I did not take responsibility for it in the way I have come to understand. I was a puppet without a brain following the instructions of the day—forcing a shallow knowledge of science on my students using a didactical way teaching. I could see little positive response from my students, either in their attitude to science or what they learned. I became bored and without purpose echoing the ways of my students. What I did not immediately recognise in those very early days was that I could have been more active in challenging the didactic methods of the time by finding better ways to engage my students with science in a better way (Whitehead, 2008, p. 107). After the early years, I was more questioning but my questioning focussed on pedagogical content knowledge (Shulman, 1986) and I became adept at helping my students understand the concepts of biology.

I believe my writing in *Bringing a heart* introduces the first time I found a place in my heart for teaching my students not only teaching biology—it was the first time I felt responsibilities for teaching that went beyond the content of my subject and beyond the money deposited in the bank each month. The sense of responsibility I was beginning to feel as a Year 11 and 12 teacher after my interactions with the 'group of 4' made me rethink if my place of teaching was truly wed to Year 11 and 12 biology teaching, even though I loved the subject. I felt a niggling sense of doubt that perhaps I did not do enough to help students vying for places in tertiary education achieve the higher marks they wanted. It was not an external demand, it came from within me and reflected the disharmony between who I am and the system of selection for a place in tertiary education. It was why I took my heart to teaching Year 7 and 8 students, because here I could be who I am.

I stop to listen to the words of an anonymous teacher from a school in London who writes,

> It was when I realised I was bored during one of my own lessons that I knew something was wrong. Teaching is a lot of things, but boring it *ain't*. And if I was bored, how could I possibly be inspiring my class?...
>
> Sure, the children still come out with unexpected responses; providing me with hilarious anecdotes and often making me smile. But the job itself now resembles that of a factory production worker. I clock in, deliver the lessons planned for me by some anonymous educationalist, read the stories chosen for me by some book marketing company, send the kids home and then mark the books using the marking and assessment code designed for me by some senior leader with no class of their own. Bit by bit, the autonomy of teachers is being chipped away at by people who don't trust us to be able to plan effectively for the children we teach. (Anonymous, 2013)

It is so close to what I wrote in *Bringing a heart* and the words 'don't trust us anymore' come back. To demonstrate my trust in primary teachers as they use aSCuPTaS I have, as curriculum-maker, given them responsibility for designing unique units of work for their students. But the idea of responsibility and the elusive balance between the need for not too little and not too much leads me to think more about how this balance can be achieved.

It all became too much

I began to feel greater responsibility
For my students, not only my subject
Especially those with difficulties

My motivation to teach soared
I got to know my students.

I thought about teaching and learning
As more and more students
Showed reactions of disinterest
To the teaching they were receiving.

My motivation to teach my students remained
But suddenly I found too much responsibility
I was overwhelmed.

Nobody in this age of freedom wanted to take responsibility
For sorting the mixture of resources becoming available.
That came as suggested activities—derived from ideas
That became the fashion of the day
How children learn
What they should learn and
The freedoms they should have.

Ideas became FADs—intense and widely shared enthusiasms
Especially ones short lived.
In Australia the words became entangled
In school names, mission statements
Curriculum documents.

FADs focused on students and
What teachers should provide and
What they should measure to find the
Effectiveness of their doing.

It wasn't just me
It became too much for many teachers
Who lost heart and with their heart
Their motivation to teach
Their responsibilities as a teacher.

I have introduced the word 'motivation' because some primary teachers are losing their motivation to teach (Anonymous, 2013; Stroud, 2016; Margolis, 2016). My motivation to teach beyond my subject, had grown in the latter half of my teaching career as I assumed greater responsibility for my students but it almost came asunder when the responsibilities became ones I felt I did not have the capacity to handle in the context of my teaching life and found myself hovering in a space of balance.

I began to question further who takes responsibility in science education. Seidel refers to the responsibilities that come from accountability (Seidel & Jardine, 2014, p. 145). I believe these external pressures shrink the space teachers have for taking responsibility for their students. With responsibility removed they lose their motivation to teach and their ability to stay positive, they lose their heart for teaching because they are "trying to do the impossible" (Stroud, 2016). These external pressures I find beyond my capacity as curriculum-writer, except by saying I make no accommodation for summative assessment in aSCuPTaS in *Communication as Assessment*, Chapter 3.

As curriculum-writer, my writing helps me know with more certainty why I believe primary teachers are in the best position to build relationships with their students by planning the way they teach science. I am comfortable with this decision because I hope I have been explicit and careful about what and how much content I include in aSCuPTaS and I know my purpose in writing aSCuPTaS is not only about a body of knowledge as van Manen writes,

> We may always feel indebted for the rest of our lives to a parent or to a teacher even though the material that we learned from this person may have lost its relevance. In part this may be due to the fact that what we "received" from a great teacher is less a particular body of knowledge or set of skills than the way in which this subject matter was presented or embodied in the person of this teacher—his or her enthusiasm, self-discipline, dedication, personal power, commitment, and so forth. (1991, p. 73)

I must remember that one of my responsibilities in writing aSCuPTaS has become one of transforming the minds of primary teachers so they understand that the self-efficacy they need for science education is not so much about their knowledge of science but about their pedagogical competence to engage their students with science in a responsible and ethical way. In other words, their role is not only so more primary students might come to secondary schools with some knowledge of science but so they come with an enthusiasm and love of science that reduces the possibility of primary students coming to secondary schools already expressing little interest and loss of connection to science or scrambling to hide their frailty and uncertainty.

My writing in *A primary gift of science* helps me understand the trust I place in primary teachers to take responsibility for translating the science written in aSCuPTaS and create units of work that engage their students with science. I talk of the advantage of their 'Jack of all trades' brain, of their knowing of their students and the resources and facilities of their schools where they teach that will make these units unique, tailored for teachers and their students.

Slowly, through my writing, I am awakening to my pedagogical responsibilities as curriculum-maker, and repeat a few words from Chapter 1, "Their varying degrees of knowledge I could accommodate, their strong preconceptions of science I found more disturbing" (p. 7). These are words I spoke of young girls coming into their first year of secondary school science. How close they are to ones I might say of primary teachers. I believe that if I can transform their preconceptions about teaching science and their self-efficacy for teaching primary science their understanding of the science they are teaching will follow. With so many generations between me and those who might teach this science, the ways of our teaching might differ but the objects and notions of science might conjure "soft feelings of birds and stars, of seas with fish and seeds that live, of worms that wriggle and dinosaurs and tides of time and wheels and bikes, boats and baths and how and why, what if and wow!!" (p. 7).

I left the clamouring of school and education with thoughts of responsibility echoing in my ears. I had questions about who takes responsibility for the different facets that become science education that remained unanswered. I felt there was something more I could do as curriculum-maker so my support for science becoming a responsibility for primary teachers would not become 'the straw that breaks their back' and to suffer in the way I had in my teaching years when change and overload were common. I thought again of how close I came to losing heart because I found myself becoming too responsible for making decisions beyond the capacity of my place of teaching and I ask yet again how much responsibility for science teaching I can leave with primary teachers and what is the balance I have looked for in aSCuPTaS? The ideas that came segue to my writing of opportunities and spaces.

SPACES FOR OPPORTUNITY

These thoughts of spaces and opportunity have taken on new meaning for me as my role changes from teacher to curriculum-writer. I retell how they came to mean so much to me first as a teacher but now as a curriculum-writer.

Spaces as opportunities include some ideas of what have been called ‘general capabilities’ and ‘cross-curriculum priorities’ in the *Australian Curriculum* (2017). In my role of curriculum-developer, I find part of my responsibility is to provide, as part of aSCuPTaS, a guide that helps teachers include these notions as they write their science units. My ideas, although they introduce some ideas that coincide with those in the *Australian Curriculum*, extend beyond these. I see my purpose in their inclusion as perhaps more like that of Jardine when he writes,

> free spaces keep being opened and kept clear in real classrooms and real schools. Spaces are opened up where things can happen to us, and our lives can be shaped with some graciousness and mindfulness. (2012, p. 11)

I like to think of these opportunities as ones children may or may not have interacted with in their lives outside school—they are ones I find too valuable to leave to chance. Some allow us to think more deeply than we ordinarily do. I am not sure if I ever found time to say to my children, now in their late thirties, “What would you think if you woke up in the morning and heard no sounds of birds?” I know I have now said these words to my five-year-old granddaughter—it took us to places unimagined, this simple open-ended question that led to conversation. Of course this conversation did not take the linear route of the one I describe as we wandered in and out of ideas in the following confabulation.

This is why

It’s very quiet when we wake up.
I think the birds have gone to China.
Why?
I think the birds are too hungry.
Why?
I think it’s too cold for their food to grow.
Why?
I think it is winter.
Why have they gone to China?
Because you read me the book, Baba
Which book?
‘Circle’ Baba remember (Jeannie Baker, 2016)

My turn now
I think I woke before it was light
Why do the birds wait for the light?
Why does it sometimes get light late?
And so it goes on …
This is why we leave space for conversation.

This is why is a simple example that points to my purpose in making space for open-ended questions minds can explore—it is one example of what appears on my list of ‘Opportunities to Grow’.

Each item on my list brings its own story—too many to tell, each inspired by something I heard, something I read, something I tried or something I felt. It helped as I designed activities for students to interact with science—a checklist I used as a reminder to make space in my planning for pedagogical ideas that are not mere strategies or techniques—ideas that come before strategies and techniques and go beyond. Many people earned my respect when I was teaching, those whose ideas provoked my thinking about my practice and encouraged me to delve more deeply. Some I remember by name, and mention in my writing, but others are names now locked in secret pockets of memory from which the sense of ‘good’ they spoke continues to seep without revealing it source.

Some of the list’s main ideas connect to the development of intellectual capacity, some to the multiple ways communication takes place, others to the environments where communication takes place and others to the need for experiences that come from our hands, not only our brains. There are no rules for how my list might be used but I believe it represents the responsibility we must take for providing these opportunities as we teach. I found it reminiscent of Dewey's writing in *My Pedagogic Creed* (1897), written 120 years before the year I write but still find relevant. It is a list I hand to primary teachers through aSCuPTaS as a reminder of the integrity and responsibility of being a teacher, of their role of teaching.

My contact with those who find a place on my list was often determined by the opportunities provided by my school or the Education Department of my State. My mentors may not have been the only ones working determinedly to help teachers create a more inclusive and active practice, which was my essential aim as a science teacher. I also know there are thinkers whose ideas brought uncomfortable feelings with what they asked of me—they never found a place in my teaching.

'Opportunities to Grow in Science' is a rather unassuming name for ideas that became entrenched in my teaching practice and is my way of respecting the mentors who contributed to my own transformation as a teacher. It is a personal list and perhaps only a starting point from which I would continue if I had stayed teaching. It evolved as I focussed on re-forming my ideas of pedagogical responsibility and competency and needed to be reminded of opportunities that might bring the 'good' of van Manen to my practice. I share my list in aSCuPTaS because of the benefits it brought to my practice, particularly as a tool for planning. For too long, as a teacher, I received complex explanations and instructions on how to proceed—usually they proceeded to the bin, there was no time to read or if I did I often could not understand. This is why my list appears in such a simple form in the Appendix.

My mentors spoke of many things—habits, pedagogy, questioning, thinking, learning and assessment, and presented ideas to ponder that have no easy answers. My checklist revolves around teaching and the spaces teachers might provide for learning to take place—physical and mental spaces teachers choose as they plan. They are ideas easily lost in the melee of activities without purpose, if we are not careful. Like the principles I speak of in the previous chapter, there may be nothing unique about the checklist except I understand the purpose of every word it contains. It is mine. When I was teaching, it became my planning ‘bible’—it was my ‘faded green textbook’ not for the content of science but of my role as a pedagogue. I am not so sure of its wider relevance but include it more as a starting point.

To make these spaces is to teach. Palmer writes,

> Space may sound like a vague, poetic metaphor until we realise that it describes experiences of everyday life. We know what it means to be in a green and open field; we know what it means to be on a crowded rush hour bus. On the crowded bus we lack space to breathe and think and be ourselves. But in an open field, we open up too; ideas and feelings rise within us; our knowledge comes out of hiding. (1983/93, p. 70)

Our knowledge comes out of hiding—I have watched it happen many times in these spaces and may become more necessary in a time when

> our living presently might already overwhelm us. Some of the children I know have already suffered a lot, more than any one human being should in a life time. Some of them are exhausted and are in desperate need of a healing place, quiet, joyful, community. (Seidel & Jardine, 2014, p. 179)

Now I find myself as curriculum-writer, I write some words from Seidel again, “Some of them are exhausted and are in desperate need of a healing place, quiet, joyful, community” (2014, p.179), and I think not of students but of teachers. I found teaching beginning to overflow with activity as I moved towards retirement. When I wrote my list of opportunities I was permitting myself as well as my students to sometimes find a space to pause, to breathe and hear the sounds of quiet. I hope the teachers for whom I write aSCuPTaS also recognise the need to pause, to breathe and refresh as part of their pedagogic responsibility to themselves.

SPACES OF CONNECTION

> "Come forth into the light of things, Let Nature be your teacher."
>
> — William Wordsworth

Wordsworth's words represent the essence of my purpose in the writing that follows—the connection to nature that feeds the soul.

I look particularly at how in science education there are many opportunities for experiences that might help children develop connections to notions of responsibility and spirituality that might remain long after they leave classrooms behind. This is to look at science not only as the explainer of the world we live in and the healer of pain but as a reminder of the continuing necessity to question the ethics of science and look beyond those things for which for which scientists already have an explanation to those for which science cannot yet offer an explanation or that the methods of science may never bring answers. Phenomena such as the source of our world, the universe and our need to establish our belief of why we are here and get a sense of responsibility and humility for what we cannot understand. I write of my brother.

David 1946 - 1993

It began when he was just nine years old
I was only four
A fascination with the night
To know the stars that twinkled there
Each night a change for those who watch
As we spin and slowly travel round
The centre of our solar place
So small we are in this immeasurable space.

He was perhaps fourteen when he first heard sounds
From far away collected in the bowl of a radio telescope
In the Cheshire countryside.
Extra galactic sounds that captured
His imagination to explore
To the point he thought beyond exploration.
He spoke to philosophers
And spoke to members of the church

And added another qualification
To his many—theology
To speak of possibilities for his dilemma
Because he couldn't understand any more

He died with a crucifix in his hand
Which made me sad
It took some time to know why
I understand more now.

I am beginning to understand more about this need to find a place of knowing of yourself. Palmer writes,

> With the mind's eye we see a world of fact and reason. It is a cold and mechanical place, but we have built our lives on it there because it seemed predictable and safe. Today, in the age of nuclear science, our mind-made world has been flawed and dangerous … (1983/93, p. xxiii)

My brother's "mind-made world" could go no further without a spiritual comfort—my mind often goes no further than our responsibility for the visible. The gifts of the natural world are the spaces where my spirit rekindles. I feel the need to protect these gifts, as we watch them slowly degraded by us who should be responsible. I compare the gifts that rekindle my soul to the children we are given to teach, where our responsibility is not to degrade but to enrich. And it is with these children in mind I pursue the idea of how these opportunities can be brought to children through science. I tell a story of an out-of-classroom experience that grew in a way that brought opportunities for the germs of the unanswerable to be introduced and ideas of responsibility, faith and spirituality to be spoken.

Gould's Lagoon 1

Clipboards, pens, paper
Worksheets blowing in the wind
You carry the bucket—you take the net.

Choose six water-birds
In what ways are they the same—different?

Find three organisms—not birds
Describe them
Use the net—what did you find?

Three plants.
Ask for the book to find what they are
Back on the bus—We have to go now
You carry the bucket—you take the net.

Write a report for homework
Hand it in—I mark it
Over for another year!

This was an annual activity part of the unit on diversity, which I talked about in Chapter 3. It was fun, it was chaos, it was to do with science and focussed on science principles. For teachers it required preparation and organisation, followed by the marking of homework we always felt was necessary to justify the excursion. At the time I thought of it as an engaging activity worthy of the preparation—it was, but I would work differently now.

Gould's Lagoon 2

Bring a camera—I have some spares
Drawing materials—writing gear
Yes, we have buckets and nets and the books.

Remember permission forms
Sunscreen—drinks—lunch
No plastic wrappings—in a backpack
Remember a sun-hat—raincoat too
Yes, bring your epi-pen—just in case.

We break into groups
Walk for a while and talk
About what we see on the pond—sometimes
We meet and talk again—about possibilities.

Have lunch—why no plastic wraps today—or any day

And wander off with camera, or notebook
Drawing stuff—half an hour of quiet in the sun.

Tonight I want you to think about why we came here—What did you see?
What did you hear? Who had been here before?
Has it always been here? What might have been here before?
Before that? Before that?
And then we'll start to look more closely
At the science.

My visions of the two out of classroom experiences have changed considerably. Both were excursions to learn about science in a different environment. The purpose of *Gould's Lagoon 1* centred around understanding specific science ideas—it was busy from the start and the busyness continued into a night of homework for our students followed by marking for teachers. In its reincarnation, I imagined *Gould's Lagoon 2* as an opportunity for the development of students' sense of respect and appreciation for the natural world. It would be a space for absorbing, a space for thinking and a space of few words. As Palmer reminds us, "Words so often divide us, but silence can unite" (1983/93, p. 81). Only on our return to school would we turn to the science of the already discovered in this natural world, to ponder why and what we might need to understand if we are to preserve the beauty of our encrusted Earth.

There was little time for thought on those first visits to Gould's Lagoon with jobs to be done, questions asked and answered. Those present at *Gould's Lagoon 2* may keep in their conscience small thoughts of the wonder of life on our Earth and I make spaces in aSCuPTaS to remind us that we must make opportunities for relationships to the world. Seidel writes,

> Have we lost our home? Our voices? Our selves? The possibility of ethical pedagogical relations? If we understand that self only exists in relationship to the world then the severing of relations is a kind of extinction of self, a profound emptiness that can never be filled by literacy programs and other busy things unrelated to the ground of our life being. (Seidel & Jardine, 2014, p.141)

As a science teacher, I found it my responsibility to leave space for questions that flow from experience. *Gould's Lagoon 2* shows how small spaces can become bigger spaces if they bring students an appreciation of science that motivates them to take responsibility for the world we live in. To imagine the change in the nature of the excursion came as I grew to understand science as more than the concrete and objective and the solution to all that we see. To add spaces for spiritual thought to my pedagogical responsibility as a science teacher has been a conscious decision on my part, a pedagogical decision, but I hesitate to call it a technique or a method or write details in aSCuPTaS. Instead I think of it as an opportunity that can easily become part of science education if allowed to pass unobtrusively through the membrane of the infallible—an opportunity to think about how we exist in relationship to the world.

It was another opportunity to introduce ideas of spirituality and mortality in the gentle way I saw happening to students when we took them on outdoor education programs and sat in silence under starry skies as the waves crashed on the beach and birds bid their last calls of the night. I offer this opportunity as part of aSCuPTaS because it might motivate students to continue thoughts that might have been initiated through their connections to science and take them beyond the four walls of a classroom. It seems scant recognition to write the importance of this opportunity as a mere question in a checklist. I believe a few words are enough to offer the invitation, the rest I hope comes from the integrity of the teachers I trust.

> We can prepare and invite, but preparation and invitation do not cause arrival but simply strive to set out some of the conditions of its possibility. (Jardine, 2012, p. 11)

THE WORDS OF MY SPACE

There are many words that appear rarely or not all in aSCuPTaS or in the writing of my thesis—words that have become more common than I would like in my vision for primary science. I have focussed on the many words I see as important to curriculum-writing, they are the words that have become the tree of my teaching life. They are not words I pull from the traditional, theoretical areas of curriculum-making, they are words that have come from my attendance "to the things of everyday life as they [have presented] themselves to [me]" (van Manen, 1982, p. 47), in what has been my life from the day I was born. I was born to teachers and have been taught or been the teacher for my sixty-six years—as a child, a student, a teacher, a mother, a grandmother and now as a curriculum-maker.

FIGURE 2
The Tree of my Teaching Life

aSCuPTaS is an echo of my world. The words of my practice that I show in the *Tree of my Teaching Life* are words I have come to respect in all my capacities as a science teacher. Many appear in aSCuPTaS, and have been present, even if not visible, and heard in my making of aSCuPTaS because they are me. The words of my tree are the same as the ones I give to primary teachers, because as curriculum-writer I am also a teacher, a pedagogue. My words to teachers are simple reminders for those of us who live the complex and responsible lives of classroom teachers and have little time for reading too many words because our time is for teaching.

The words of my tree have been sifted through the net of my experience—some have been dropped because they make little sense, others have been combined to words of generality. The ones that remain are ones that ring bells of truth for me.

COMPOSER, CONDUCTOR AND ORCHESTRA

I began this project believing generalist primary teachers should take responsibility for science teaching in their schools because of the advantages this might bring, and I had an intuitive vision of how the words of my experiences might be re-imagined into a curriculum for primary science teaching.

In this chapter and the previous ones, I have reflected on my teaching life that led to this vision to get a measure of how my understanding of science teaching and evolving purposes of teaching science were relevant to primary teachers and the curriculum of my vision. It resulted in a curriculum in which I redistributed the responsibilities for curriculum actions between the writer and teacher so that a curriculum for science teaching might become more appealing to generalist primary teachers. I write now not of a theoretical vision of what that curriculum might look like—it is here now as aSCuPTaS. Rather, I look at how it might look like in practice by comparing the interacting and intersecting roles of curriculum-writer, primary teachers, their classes and the individual students in their class with that of composer, conductor, orchestra and the members of the orchestra.

The Conductor

The conductor
Invites players to life—the cellos, the flutes
And the bold and bright brass
She makes an appeal to the first violin.
He plays with panache
The triplets, the quavers and pauses that spilled
From the notes of composing
He has made as his own.
He returns to his place as the
Cello replies—with soft tones of echo.

They work as a whole—they work in small groups
In response to conducting that brings them
To listen, respond creating a whole.
Sibelius perhaps—Dvorak, Mendelssohn, Mozart too

Beautiful notes strung to beautiful sounds
Carefully crafted creative work—an opus.

At times the conductor might stand aside
To merge with the group—more common in jazz
He calls to those who share their prowess to shine and standout
To move to where the music leads.
The audience claps—the audience cheers
The soloist bows
Her friends stand in awe at what they have heard
Inspired.

The conductor makes use of opportunities offered.
Her conducting's not needed if there are no players
The orchestra collapses if she is not there.

A complex concern to bring
The best of each member to the whole of the group
The audience knows—they clap and they clap
For conductor and orchestra
Calling them back again and again
Until they play more.

The performance is over—they go quietly home
The orchestra—conductor—audience too
Each thinking again of what they have seen
Each hearing the notes of what they have heard.

The composer may watch—or may even listen
From heavenly heights
Or perhaps he just gazes beside distant lakes at
Waters that quiver, at birds that can sing
Bringing light that may kindle his heart and his mind
Inspiring another, another, another.
Bringing light that may kindle the hearts and the minds
Of players, conductors and all of mankind.
No one can play without the other—in harmony.

As conductor, the teacher should receive considerable recognition, for to conduct music is a complex responsibility, one that aims at bringing out the best of each member of the orchestra to produce a whole.

Like the conductor, a teacher needs to be flexible. In their role they might move from leader to group member but there are responsibilities that will not leave them—the responsibility to provide their students with opportunities to learn about science. There is nothing nebulous about this role, it is one that requires discipline and constant vigilance on the part of the teacher but as is often said, if thoughtfully done, the student may learn without recognising the leading role of the teacher.

Students are the members of the orchestra—no conductor would be needed if there was no orchestra—no teacher would be needed if there were no students. Students may need to be led to understand the science, but they also come with knowledge, skills and qualities that contribute to make the experience richer. They need to be disciplined, to attend to the conductor, await their cue and practise so they can contribute when needed. They need to respond to the call of the conductor and make use of the opportunities being offered. They will be inspired by what they see others able to do. In this sort of atmosphere students and teachers will learn to respect each other and grow.

It is because primary teachers are acknowledged for their pedagogical skills I ask them to play the role of conductor but as the curriculum-writer I too must play a role. My role has been to provide the opus—aSCuPTaS—a small token of appreciation of what I know happens next. My purpose as curriculum-developer is to encourage teachers to provide opportunities for their students to develop a deep understanding of significant science that is set in a broad context. I am responsible for identifying the science and ensuring my curriculum is accessible to the teachers who will use it. Class teachers focus on how they bring all students into a circle of science learning, use formative assessment to support student learning and encourage the use of generic skills so that what their students learn in science might be useable in a wide range of disciplines to help students.

In Biesta's terms (2015), I am handing agency for primary science teaching to generalist primary teachers. My vision, in the manner of Biesta, is not of teachers as facilitators or organisers—their role is more complex. It is interactive and requires constant judgement and decision making as the children they teach respond in their individual ways. The role of teachers is to make aSCuPTaS live in the same way that conductors bring life to the composer's vision.

I carry these ideas with me to Chapter 6 when I talk about the curriculum I have developed for science teaching in Australian primary schools. These, together with the knowledge I take from the previous three chapters and Chapter 5, have determined the final form of my curriculum. A curriculum derived from intuition but now standing more firmly on a bed of understanding.

MEMORANDUM — WHAT I TAKE WITH ME

I stand on the cusp now, aSCuPTaS in my hands awaiting judgements beyond my own. Ones that would come from an unexpected opportunity I write of in Chapter 5.

My writing in this chapter returns me to memories, but also brings opportunities for speculation about the sources of gifts that primary teaching might bring to the teaching of science. Gifts which perhaps come from sources not easily identified and effects needing exploration that might bring fresh ideas of what it means to be a primary teacher—the attributes this requires and the need for the subjectivity (individuality) of teachers to be recognised. Biesta recognises the need for different educational responsibilities because we need to

> realize that our educational interest in the emergence of subjectivity is not to be understood in terms of production, in terms of strong, metaphysical creation, but rather requires a different kind of educational response and a different kind of educational responsibility. (2013/2016, A Pedagogy With Empty Hands)

I translate this into a need for us to think who it is we give the gift of an opportunity to teach in primary schools and who takes responsibility for this. As Dewey writes,

> I believe that every teacher should realise the dignity of his calling; that he is a social servant set apart for the maintenance

> of proper social order and securing of the right social growth.
> (1897, Article 5)

Dewey adds that, “Existing life is so complex that the child cannot be brought into contact with it without confusion or distraction” (1897, Article 2).

Dewey talks of children, I talk of my responsibility to primary science teachers and the responsibility they have to the children they teach. I continue with these themes in my following chapter.

CHAPTER 5

A GIFT OF LOVE AND FRIENDSHIP

Of all affairs, communication is the most wonderful.

John Dewey (1929, p.166)

The title of this chapter introduces the idea of a gift, but in a different way to the way I spoke of a gift in Chapter 4, when I pondered what it might mean to have a gift for teaching. I wonder if the gift of Chapter 4 may be hidden in the inner workings of who we are and might only be revealed when we begin to know ourselves. In my writing in this chapter I speak of a gift accompanied by conscious thoughts in the way van Manen (1990, p. 115) writes. He refers to Langeveld (1984, as cited in van Manen, 1990, p. 115) who says of a gift, "whoever gives a gift (and not just a mere present) gives himself or herself. He or she is the thing". I am the thing aSCuPTaS, my hope is aSCuPTaS can be received as a gift, something given with thought and responsibility, not a mere present, which Langeveld (1984, in van Manen, 1990, p. 115), describes as fulfilment of an obligation or debt. The two ideas of a gift from within and a gift of consciousness are likely entwined in our role as teachers, making our gifts to the students we teach partially sourced from our natural propensity for teaching and our consciousness of the purpose of the gift. I use the word 'consciousness' in a way that links it to responsibility and purpose—a gift of consciousness is one that is made with an understanding of the purpose of the gift and responsibilities of the giver in making a gift suitable for that purpose.

In writing aSCuPTaS I have no obligation or debt, only "my need to do something rather than nothing" (Chinnery, 2017) for those primary teachers who find rekindling the light of science in their hearts and minds challenging—to make this gift I have taken time to think of those I give it to, both teachers and their students. Through aSCuPTaS I offer opportunities to lower the energy of activation that might make some reluctant to teach science. I hope my gift immersed in love, respect and trust, might open spaces of possibility where primary teachers may regain their trust in themselves to teach science and the gifts this might bring to their students. It is the life-affirming energy and values I began to see when this gift of aSCuPTaS began to circulate that helps me to recognise the trust I place in my living standards of judgement (Whitehead, 2008, 2009) that resulted in aSCuPTaS, and they are well founded. Making judgements based on my living experiences of teaching and curriculum-writing has been a fundamental part of Chapters 3 and 4—they are the product of who I am, my educational values and the trustworthiness I have found for my own practice from others that make them more than my personal thoughts and opinions.

aSCuPTaS is a curriculum that emerged from my practice of teaching. My living theory of what it is to be a maker of a science curriculum for primary teachers echoes my experiences of its birth. Whitehead writes of the need for validation of living theories.

> Since 1976 I have used a process of democratic evaluation, described by MacDonald (1976), together with the four criteria of social validity proposed by Habermas (1976), to strengthen the personal and social validity of living theories. By this I mean that I submit my explanations of educational influence to a validation group of peers with a request that they help me to strengthen the comprehensibility, truthfulness, rightness and authenticity of the explanation. (2008, p. 108)

Before I submit my inquiry to validation in this way, I return to the words of Dewey (1929) that appear at the beginning of this chapter. Without communication, the gift of the title of Chapter 5 may never begin its journey. In this chapter I write narratives that help to assure my growing faith in aSCuPTaS as more than a present but a gift to primary science teachers and the students they teach. It is a gift I hoped could speak with teachers in my absence, because I want it to communicate with those who are real and present in our schools, but may be without the guide of a teacher. It is a gift of science from me to primary teachers so that through their thoughtful translation the gifts of science will become appreciated by their students. In this chapter I explore whether my hope of communication is achieved.

Before I write more in this chapter, I ask you to return to aSCuPTaS to browse with an eye of imagination. I ask you to use your imagination to envisage the potential and possibilities aSCuPTaS might bring to primary science teaching. Remember, aSCuPTaS is a not a gift of perfection. It is a gift of thought that might stir our imaginations of what might enhance our practice of curriculum-writing for the teachers of science in primary schools so they can introduce the wonders of science to their students from the earliest years.

Imagine whether aSCuPTaS might bring energy to your teaching of science to a class of twenty-five students if you were a teacher with some teaching experience but not of science, without much science background and without much confidence to teach science. Imagine if you had little time for science teaching, few facilities of the sort traditionally used for science teaching in secondary schools, little support from colleagues whose experiences of science are very much like the imaginary 'you' of my writing. Would aSCuPTaS bring possibilities for teaching science when for many years you have imagined your role is to take responsibility for literacy and numeracy and the requirements for external assessment that accompanies this?

As I began to understand primary teachers more than when I first wrote PaSCuPTaS these words are ones that tumbled from my mind.

Re-imagination

The words came to make sense of what it means
To teach science in primary schools
To kindle the light of science to shine
In the hearts and minds of primary children
And their teachers
Because some might have clouded minds
Of what it means to teach science
That saps their energy to begin.

My mind says to teach science is to engage
To observe, to explore, to experiment and bring wonder.

Shared words that come over and over again
Good words that become shadowed by darkness
That creeps from expectation if we are not careful.

To bring light through faith and mutual responsibility
Was my purpose in writing—a curriculum
For primary teachers so they could create wonder
And love, community and conversation, inclusion and sharing
To become the possibilities teaching science might mean.

I have trust you can, I have faith you will
If I accept my responsibility to give small props of support
And spaces to work that bring good to you and your students
And help you to understand the science that you teach is not
'Rocket science' but science you know but may have
Not found a space to think what it means when you teach.

I write with words of simplicity, with explicit words, of
Questions to ask and what you might do
To engage your students with these notions of science.
Your children will often distract with ideas
Of their own—you cannot answer.
Acknowledge your frailty with the truth
And use your resources or theirs
For possible ways to more certainty.

Responsibility—a shared responsibility becomes
The centre of my writing and the return of the 'faded green textbook'
With the added knowing of what it is to teach
And the mutual trust of
Those like us who teach—for love and respect
And to kindle the light of science to shine
In the hearts and minds of primary children.

In this way—the energy of the light of science circulates
As we plan and work in conversation and communion.

This latest writing sees me increasingly understanding the similarity between my role and responsibilities as curriculum-writer and who I was in my role as teacher of science. It sees me becoming more understanding of the responsibilities I accepted in writing aSCuPTaS and the risks I would take to support generalist primary teachers to take responsibility for science teaching. In my writing I frequently speak of risk and "*The Beautiful Risk of Education*", words borrowed from Biesta (2013/2016) that helped me make more sense of the experiences I introduce in this chapter. Now I write other words from Biesta (2015) that reveal how teacher/student relationships and curriculum-writer/ teacher relationships become intimately connected in my thesis. Biesta writes,

> In plainer language it means that students not only learn from what we say, but also from how we do. They often focus more on how we do than on what we say, particularly if there is a (performative) contradiction between the two. Teachers therefore also need to make a judgement about the appropriateness of how they teach and organise their educational efforts. (2015, p. 79)

I hope through aSCuPTaS it will become clear that I have taken responsibility for the judgements I have made “about the appropriateness of the way [they] I teach [through aSCuPTaS] and organise their educational efforts” (Biesta, 2015, p. 79). I have made these judgements in relation to teachers’ interactions with their children and science, and hope my way of doing this is not by judging their performance

> … in a particular domain by threatening them with punishment if they do not perform well or by promising them money if they perform well. But the question is whether the messages [I] convey with this are those [I] deemed desirable for the education of our teachers” and through them our teachers. (Biesta, 2015, p. 79)

ILLUMINATING LIVES

I speak of the unexpected opportunity I had to introduce aSCuPTaS to and work as a mentor with a group of teachers who had classes from Years 1-4 in the primary section of a larger school The principal was concerned because she believed the science being taught was not science but social science and there was no consistency in the opportunities students had to learn about science. I refer to the Year 1-4 section of this school as 'Imagined'.

My original way of seeking evidence that the words of aSCuPTaS could speak to and support primary teachers to teach science was to ask a small number of teachers to use it and then interview them about how they had found it. Having the opportunity to work alongside primary teachers eliminated one of my original ideas of seeing if teachers could use aSCuPTaS without a mentor but introduced opportunities to work with them as they developed their units and speak with them after they had taught their first unit with their students. These opportunities were invaluable and allowed me to see the difficulties that might have arisen if I had not been present as a mentor.

I believe this way of working brought greater benefits for me as curriculum-writer as I could interact with, observe and listen to the teachers as they worked with aSCuPTaS—opportunities that might show whether aSCuPTaS provided sufficient support for teachers to write unique, site-specific units that engaged their students with science. I feel to act in this way has been more responsible towards teachers and the students they teach and a more effective way of gathering feedback than my original thoughts.

As mentioned in Chapter 1, Parlett and Hamilton (1972) introduced the idea of illuminative evaluation as a way of evaluating new programs, particularly in education, using qualitative methods—methods that removed the necessity of acquiring information quantitatively, often over many years, by which time the program in question had often been replaced. It was a method that allowed me to make adjustments to aSCuPTaS as it was used.

I worked closely with eight primary teachers using aSCuPTaS and write a little of 'Imagined', its teachers and children because it gives a context for my illuminative evaluation. There were two classes with between 20 to 24 children in each year group and eight teachers, all female with six out of eight under the age of thirty-five. In my writing I refer to each of them by a fictitious name—Alice and Anna, represent Year 1 teachers, Bec and Bee Year 2, Carol and Cath Year 3 and Di and Daisy Year 4. Di has a science degree, Bec, Bee and Carol continued with science until Year 12. All had completed science until Year 10 and had some experiences of science teaching in their teacher education programs. Year 3 and 4 teachers had large, new classrooms with wet areas, but Year 1 and 2 classrooms had more limited space with only two small wet areas and a shared oven. Students did not have personal laptops but had access to shared computers in each classroom, cameras and art materials were readily available.

Science was an acknowledged part of the curriculum—all teachers had one afternoon a week designated as science. It was approximately 90 minutes but often eroded because of other activities within the school. The teachers indicated they usually only managed two out of three weeks, an average of 60 minutes a week. There was no written document for science, although there were certain assumptions about what science would be covered at various times, these were vague statements such as, we always do chickens in Year 1 and in Year 4 children participate in a national science talent search. Overall I would describe this school as privileged as far as the facilities and resources were concerned. It had a stable and dedicated staff, children from higher than usual socio-economic backgrounds and a science program in place.

The grounds of 'Imagined' were extensive, giving access to a small rivulet and bushland and it was close to the normal facilities of a city. School buses were available for excursions and, although there was minimal, specialised science equipment, there was a stock of useful containers and basic measuring materials, such as scales, thermometers, tape measures and metre long rulers—an 'elegant sufficiency' for the science of my imagination.

OF HOSES, BOOTS AND IMAGINATIONS

As I watched my 'group of eight' at work on their planning I found myself amazed. In the narratives that follow I share three stories from the teachers and my words of amazement that unfolded in parallel. These narratives lead into the development of my living theory of curriculum-making later in this chapter.

> *The time I spent with the eight teachers was short—a total of twelve hours during the last school term of a year, about ten weeks. We began by planning a unit for Year 1 on '*The Changing Seasons*'—this took place after school finished. To follow*

I spent an afternoon with each pair of teachers as they began to write a unit for their own class. I had changed my original curriculum to accommodate the absence of a pre-Year 1 class and to include events staff wanted to retain. I found I could quite easily adapt aSCuPTaS to accommodate both, especially the inclusion of the Year 1 tradition of incubating eggs and Year 4 classes' annual participation in a science investigation competition. To blend the old and the new to form new horizons in the way of Gadamer (1975/2004) sat comfortably with my vision of aSCuPTaS and the value I placed on retaining the 'good' of the past.

Before the end of the school year, each of the four pairs had one unit ready to put into practice early in the following year. I spent another afternoon with each pair after they finished teaching their first unit. During the remainder of the new school year three more units were completed by each pair of teachers—occasionally I was asked for help as they started to work on new units. It was during the preparation and review times I had opportunities to talk with the teachers as we worked together.

I had become more familiar with what the principal of 'Imagined' had referred to as the SOSE emphasis of science lessons. Science often seemed to have been set around a topic that had possibilities for science teaching but the connections were not always made, the ideas were conceptually difficult and little room was made for more than cursory attention to science. The work being done in the name of science was very much like the Parallel Studies program in Years 7 and 8 I spoke of in Chapter 3—teachers were providing opportunities I recognised as invaluable but not for teaching science. My purpose in writing aSCuPTaS was to bring more consistency to science teaching in primary schools and I now share some of what I saw and heard as eight teachers began to work with the words of aSCuPTaS. In this first example, Bee and Bec planned a unit on '*Materials for Keeping Warm and Dry*'. *Beware of the hose* tells of the words I heard when they had completed this unit with their class.

Beware of the hose

It all began as an introduction
To get our students excited.
They brought their boots and raincoats
We brought plastic paddling pools
Hoses and a large roll of plastic.

They walked through the water
No wet socks—their boots were waterproof.
We tested their raincoats
By hanging them on a line
With a piece of paper taped inside
And then used the hose.
Many didn't survive the
Waterproof test.

We talked a lot—asked questions
And then we did a performance.

I wrapped Bec in plastic
From the waist down
And fired her with the hose
We think we were irresponsible
And had to urge our children
Not to repeat our experiment.
Bec got wet—we talked about that.

We were ready for more next week.
When we tried ice cubes and paper
In various tests with thermometers
And the clock on the wall.
We made a class graph
We talked and asked more questions
We pinned the questions on the board
In the language of children.

The poor people who slept under paper
Brought lots of interest—our children found it hard to believe

And wrote words of how it would feel in the cold of the night.
The weeks passed until six had gone by
We learned lots of science—thanks for the questions
Thanks for the background
It is our bible.

THANK YOU for your enthusiasm I say.

Bee and Bec, who imagined these activities, were confident and competent, they were prepared to take risks for a beautiful education (Biesta, 2013/2016). They were prepared to go further and to risk what went beyond the usual. Their risk was to follow few patterns and create unique opportunities that would capture their students and bring opportunities for them to interact with science. They added science into their equation of engagement in a way that appeared seamless, their responsibility for their students shining through. Their planning throughout the unit showed thoughtfulness and care for their students and for science.

They were not the only two who astounded me with what they achieved and I add another example because Carol and Cath planned a very different unit to teach about 'Water and Soil' to their Year 3 students.

Sustaining the source

Our beginning was all about planting
In different conditions
The room full of soil, seedlings, sand and salt
Containers in different shapes and sizes
And water.
We began like this because
It takes time to grow.
I tried to keep it simple
I know what can happen—even in Year 3.

Each group had responsibility for
A set of normal plants—no sand and no salt
I hoped they would survive

To go home.

We put a plan on the wall so we—the teachers could track
What we were doing!! It was simple but complicated
With 20 eight-year-olds as
We watered and counted the leaves
On Mondays, Wednesday and Thursdays
Week one was very busy.

Week two gave us space to think—we went to a nursery.
And were shown different plants for different soils
For sun and shade, for dry and wet
It was good—we returned with two plants for our school
To plant and watch.
For three weeks the children designed their own plants
For special conditions of their choice
Sandy soil with wind and salt from the sea
For mountain homes with snow and cold
Of long winter nights.
They drew their plants, gave them names,
Made labels and wrote
About the conditions of survival.

And in these weeks we gathered and talked
And followed our experiment with photographs and
Counting.
We talked a lot about the questions
And what might happen to the animals and the people
If the rain didn't come and the plants died
In the last week we talked about
The many dead or drooping plants
Of our experiment.

It was not as hard as we imagined.

Carol and Cath found it more difficult to share in the planning and it seemed Carol, who had completed biology in Year 12, was the leader and mentor for Cath.

They brought life to a unit that could have been dull and uninviting without their creativity and their knowing of what would absorb the imagination of their students and engage them with science. It was their ability to organise such an enterprise with quite young students that took my breath away initially, but their unit was not only about management. When I heard of the 'spaces' in their lesson plans and the designing of plants that gave opportunities for individuality interspersed with conversation, I saw again the responsibility the planners had taken for their students and the way they worked science into activities they knew would be inviting to their students.

But it was the day I re-visited Anna's Year 1 room I had seen in an early visit to the school that I felt more convinced my risks in aSCuPTaS were worthwhile.

Risking the hens

At first I saw twenty-two pictures of hens
Identical photocopies of a hen
Coloured by twenty–two students.
Brown hens with red combs and yellow beaks
Birds of no risk.

In the following year
I saw twenty-something pictures of birds
Wildly imaginative birds of risk
Each with features that
Makes them birds
But birds of risk.

This was a beautiful experience and one I shall always remember. It told me that something was happening in a space where I felt there might be resistance because the eggs, the chickens and the hens had been the 'baby' of Anna and Alice. Anna and Alice had developed the Year 1 unit *'Living Things'*. The eggs, chickens and hens remained but had become birds of their wonder, and were firmly connected to some broader concepts of science.

The planning I watched taking place and the descriptions of the action happening in classrooms made me wonder if the principal had been mistaken when she asked me to introduce aSCuPTaS *to the teachers at 'Imagined'.*

Mistaken?

I thought at first she had been wrong
That science was SOSE and not science, but
They assured me that now
They understood this was right
Now they were teaching science.

And they spoke of the good that had come
Of parents who told tales
Their children brought home
Of science.

And they spoke of the questions they asked
And the way they found answers
In more ways than one
Of the graphs that were drawn
And measurements made.

The places they'd been and the
Things they had made.

There was no need for labs or equipment
To do the things they had done in the space of
The oven and rulers, thermometers and
Occasional scales.
They were resourceful—the teachers I mean
Finding treasures in trash and
Recycled things to 'make do'.

They told me they planned in an evening now
A challenge to find the risks they might take
For six weeks of opportunities unique to themselves.
They made the judgements, they had the values

And a bible so energy flowed
As they took responsibility for science.

I believed I might be giving a gift to these teachers but to watch them at work was their gift to me and it was these reciprocal gifts and their positive effects on receiver and giver that helped me to understand why I had taken risks in writing a science curriculum for primary teachers explicit in the purpose of teaching science in primary schools, in the principles and values that underpin it and the knowledge of science to be learned. To bring these ideas together into aSCuPTaS was my responsibility as curriculum-writer and my gift to primary teachers. But to bring aSCuPTaS to life was the responsibility of primary teachers and the way they responded became their gift to me and to their children.

As I walked away from my work with the teachers at 'Imagined' my mind was overcome by what I had seen. It was a transformation of social science into what I call primary science, although large elements of the social remained and what I call science might not be how others envisage science in primary schools. But it was a transformation that brought new energy and excitement to the teachers. As I explore what I saw happening at 'Imagined' in the following section, I again take a retrospective view and ask, what it is it about aSCuPTaS that has permitted the transformations I was seeing?

CURRICULUM-MAKING AS A LIVING THEORY

My thoughts are complex and interconnected, constantly arriving and reshaping with the movement of time as I sift and sort my ideas for why aSCuPTaS had brought light and energy to science teaching at 'Imagined'. Its evolution has been fed by many sources with only the fittest surviving. My respect for science teaching in primary schools brought ideas of purpose and the need for science to be thought of as more than science knowledge and methods, something more than answers to our questions but science as a human responsibility—a responsibility not to ask questions about matters that might bring harm and to know there are questions that science cannot answer. The raw materials for aSCuPTaS came from the translation of my practice and my growing understanding of change and what it means to teach for the 'good' it can bring. My practice resulted in the five principles that grew into my mantra of teaching science. My understanding of primary teachers helped me respect the unique contributions they can make to the learning of science. And my life has brought values that belong to my living and to my teaching because they are me. In the cloud of my mind these ideas had floated over many years before being caught in the net of aSCuPTaS.

In the way of Whitehead (1989, p. 42), aSCuPTaS is the proposal I believed might be an answer to my original research question, 'What might a science curriculum for primary teachers look like if it is designed to meet their needs, it is accessible to these teachers, it makes the teaching and learning of science manageable in their context and it supports them to write science experiences for their students in the 21st Century?' I find the question perhaps too constrained for what I see now and open it up in the light of my new understanding. It becomes, what might a science curriculum for primary teachers look like if it gives freedom and responsibility to primary teachers to teach science?

As I have moved through the chapters of my inquiry I have revisited the experiences that informed aSCuPTaS and asked what each had contributed and speak of the evidence that makes this contribution trustworthy. When I reached the point where this chapter begins I had accumulated answers from my practice to many questions of the sort, "How do I improve what I am doing?" in the way of Whitehead (1989, 2008, 2009). For me the questions often came retrospectively as I put into practice intuitive rather than planned and conscious thoughts—questions more like, what have I done that improved my practice? Each question took me to the place and time of the questions and answers of my practice but introduced further questions with a slightly different emphasis, how do the answers of my practice contribute to my developing theory of curriculum-making? Figure 3 that follows is a simplified representation of the contributions my experiences have made to the development of aSCuPTaS and to my living theory of curriculum-making in each chapter.

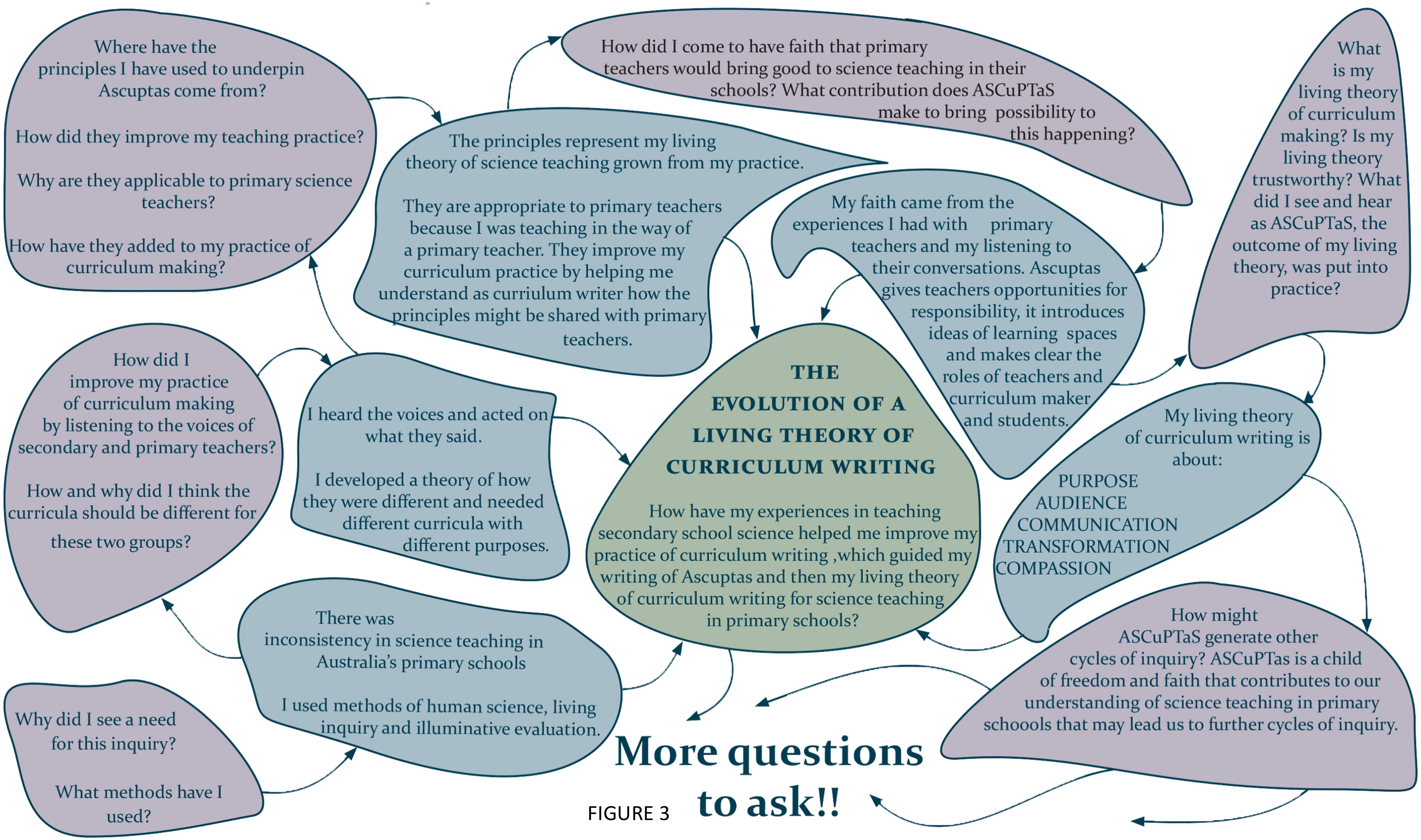

Where have the principles I have used to underpin Ascuptas come from?
How did they improve my teaching practice?
Why are they applicable to primary science teachers?
How have they added to my practice of curriculum making?
The principles represent my living theory of science teaching grown from my practice.
They are appropriate to primary teachers because I was teaching in the way of a primary teacher. They improve my curriculum practice by helping me understand as curriulum writer how the principles might be shared with primary teachers.
How did I come to have faith that primary teachers would bring good to science teaching in their schools? What contribution does ASCuPTaS make to bring possibility to this happening?
My faith came from the experiences I had with primary teachers and my listening to their conversations. Ascuptas gives teachers opportunities for responsibility, it introduces ideas of learning spaces and makes clear the roles of teachers and curriculum maker and students.
What is my living theory of curriculum making? Is my living theory trustworthy? What did I see and hear as ASCuPTaS, the outcome of my living theory, was put into practice?
How did I improve my practice of curriculum making by listening to the voices of secondary and primary teachers?
How and why did I think the curricula should be different for these two groups?
I heard the voices and acted on what they said.
I developed a theory of how they were different and needed different curricula with different purposes.
THE EVOLUTION OF A LIVING THEORY OF CURRICULUM WRITING
How have my experiences in teaching secondary school science helped me improve my practice of curriculum writing ,which guided my writing of Ascuptas and then my living theory of curriculum writing for science teaching in primary schools?
My living theory of curriculum writing is about:
PURPOSE
AUDIENCE
COMMUNICATION
TRANSFORMATION
COMPASSION
There was inconsistency in science teaching in Australia's primary schools
I used methods of human science, living inquiry and illuminative evaluation.
How might ASCuPTaS generate other cycles of inquiry? ASCuPTas is a child of freedom and faith that contributes to our understanding of science teaching in primary schoools that may lead us to further cycles of inquiry.
Why did I see a need for this inquiry?
What methods have I used?
More questions to ask!!

FIGURE 3

But whilst aSCuPTaS had evolved from my practice and sat on strong foundations it was only beginning to be seen in the practice of those I had written for. I enjoyed what I was seeing and return to my question, 'What it is it about aSCuPTaS that has permitted the transformations I was seeing?'

I turn first to the 'group of eight' teachers who felt the essence of aSCuPTaS was the 'Background Information' for each of the topics of the curriculum which they began to call their 'bible' and their lifeline. Was the 'bible' the return of the 'faded green textbook' that had become lost for me in the motions of change of the 80s and 90s? The 'bible's' inclusion may even have been lost from aSCuPTaS—it was almost as an afterthought as I pondered a way to speak in words of the knowledge of science, the methods of science and the human responsibility for science in a way that might bring more meaning to the questions I introduced in the goals of aSCuPTaS. I believe my writing in the 'bible' brings more incentive to teachers to become involved in and responsible for teaching science.

I pondered

I thought about what it could be and what I could say
Of the science that had been my life
Of hooks that might help
To get started.

I dropped notions of research
And primary programs
And went to my practice of years
To give me the words
That would help to begin
A change in perception of
Of science and
Who should take its responsibility
In primary schools.

This change in perception
Began to evoke a notion
Of why I was doing what I was doing
And my notion of why soon started to grow

When they said
Of course we know this
We just hadn't thought about it in this way before
And efficacy grew.

When I began to write aSCuPTaS I had in the back of my mind that the standard of science required for teaching in primary schools was well within the capacity of teachers who had all completed Year 10 science. I was slightly fearful of saying these words in the way I had felt when my colleagues talked of my 'watering down' the content of science or perhaps I was afraid of being accused of devaluing the science that I loved. But my last-minute decision to write 'Background Information', was a beautiful risk for education, one that could become transforming for primary teachers. I believe the details of the 'bible' guided primary teachers towards a freedom and space where they could concentrate on their responsibility of teaching. The 'bible' was more than a textbook for teachers—it was my letter of invitation to primary teachers to take responsibility for science teaching. I included hints of values, opportunities and possibilities for connections. I had inklings but no great faith that by re-creating the 'faded green textbook' of my first years of teaching I would see so much change. But the 'bible' became the life-string and centre of practice for the teachers at 'Imagined'.

This notion of risk becomes increasingly evident as I reflect on my interactions with the 'group of eight'. I had taken a risk in placing my trust in primary teachers' pedagogical competence—it was a risk about which I have no regrets, a risk worth taking. I saw the risks they were taking when they planned their units. Risks that helped them think differently about what it means to teach science and to think more positively about how they can contribute. It was a risk to write in aSCuPTaS there is no need for individualised teaching to cater for the individuality of their students and a risk to be explicit about values, purpose, content, methods, opportunities and responsibilities. It was a risk to take the intensity out of teaching science in primary schools.

I had taken risks because aSCuPTaS was an imagined curriculum although truthful to the content of the *Statements of Learning for Science* (MCEETYA, 2006). The risks I took may not have been the notions of other curriculum-writers but are grounded in my practice and understanding of primary teachers. I was able to take risks because out of my practice had grown strong beliefs in the purpose of teaching science and the values of including science in the primary curriculum. Both influenced the directions of aSCuPTaS. I believe the risks I took resulted in a curriculum of freedom and permission for primary teachers and that it was these that enabled me to see the energy and confidence this gave to the teachers of 'Imagined'—freedom to take responsibility for science teaching and permission to let the light of their own individuality shine through.

My belief is that, for both me as curriculum-developer and the teachers who used aSCuPTaS, our risks became possible because of our freedom—freedom to make judgements, freedom to take responsibility that came from the epistemology of our teaching experiences that enabled us to bring educational 'good' to our audiences. The beautiful risks of our taking, mine in my curriculum- writing and the teachers at 'Imagined' in their planning, were only possible because of their grounding in our practice.

When my connections with 'Imagined' had finished, I cast a critical eye across aSCuPTaS once more. I removed some sections I was beginning to recognise as remnants of my secondary experiences and were not applicable to primary teachers and other ones that came from conversations in my head that were important for me as curriculum-maker but not for primary teachers. Their removal left a more streamlined curriculum document. But my eye was cast for another reason—I questioned whether aSCuPTaS was merely their bible of science content or whether the values and energy I was seeing amongst the teachers at 'Imagined' could have come from the words of aSCuPTaS.

It had been my intention that aSCuPTaS provided opportunities for primary teachers to understand the values, principles and purpose of teaching science and the role and responsibility they take for choosing and using methods of science that are inclusive and give their children opportunities for socialisation, subjectification and qualification (Biesta, 2010, 2012, 2015). I found most of these ideas inscribed in the written words of aSCuPTaS and adjusted some to make them more obvious but my reading made me conscious there were some words that needed to be spoken as well as written—they are the spoken words of our conversations as planning was done and stories were told. aSCuPTaS was a good starting point but could never replace the dialogues of living and the gentle intervention of a mentor in the early stages when teachers begin to work with something like aSCuPTaS. And there are other words that remain empty whether spoken or written until they appear in our actions—I speak of belief, trust and integrity and the need for living relationships in practice between the composer, conductor and orchestra who make their appearance in Chapter 4.

At the 'Imagined' school' I saw each of the teachers transformed in positive ways by aSCuPTaS. I use Biesta's words to complete my next sentence. Whether these transformations occur, whether teachers realise their responsibilities for teaching science and the good that can come from their individuality

> is an entirely open question. It is beyond our control and fundamentally out of our hands. Keeping education open for the event of subjectivity to occur does, of course, come with a risk, because when we keep education open anything can happen, anything can arrive. (Biesta, 2013/2016)

I have few doubts aSCuPTaS provided sufficient support for my 'group of eight' to write unique, site-specific units that engaged their students with science. It showed more than this because to be there with the teachers I could feel the energy and the values that went into their writing and sense both in their words as they spoke of how they felt as they became the teacher of science to their students. I believe the potential for much of the change was present in the teachers I worked with before I arrived with aSCuPTaS but the potential was awaiting permission to be released.

I write the living theory that grew from my experiences in writing aSCuPTaS as a confabulation in the way of Berger (2016), as I find no other way to bring the extent of my thoughts together.

A curriculum of risks and permissions

The freedom of curriculum-writing
Without the constraints of politics
The demands of quantified measurements
And the dominating love of subject.

The freedom of a curriculum maker

Without ideas of what it is to be 'a curriculum'
With ideas of what it is to communicate
And what it means to act to the receiver
In the way you wish them to act
To their audience of children.

The possibilities of teachers who have chosen
To teach children and not to teach science
Whose minds might be open to change
Who have rooms of their own
A place where connections are made

Together they shared in mutual trust
What they each had to bring
For the benefits of good
That would come to the children
Through energy traces that moved this way and that
To kindle the light of science to shine
In the hearts and minds of this community
Of three.

Freedom to be, freedom to teach
With the help of the 'bible'
Respect, invitation and creation
So teachers and children could grow
Into the skin of who they are and what they can be
With purpose and risks that would blend to
Engagement with science

And the curriculum-writer watches
As the energy and gifts circulate
In sustaining the future
Through practices of possibility.

This is my living theory of curriculum-writing that comes from the 'I' of my practice in the same way as aSCuPTaS is the living theory of the 'I' of my teaching and the 'I' of Whitehead who writes "I am thinking here of 'I' existing as a contradiction in the sense of holding together a commitment to live certain values with the recognition of the denial of these values in practice" (2009, p. 87).

I have written aSCuPTaS from a theory grown from practice that brought possibilities. Without the backing of practice the risks I was taking may have brought damage not light to 'Imagined'. Using inquiry based on experience and interpretation has enabled me to take risks that are not risks so much as possibilities, informed by the epistemology of my practice. My risks were not wild, unsupported risks—they were risks I felt would bring only 'good' not harm to the teachers and students at 'Imagined'.

MEMORANDUM — WHAT I TAKE WITH ME

I leave my experiences with the teachers of 'Imagined' with hope and happy memories that come from their stories of practice, and a new respect for the magic of communication and the competence of pedagogy. To accompany the teachers of 'Imagined' as they began to create unique, site-specific units to engage their students to learn about science was a privilege that helped me recognise the power of illuminative evaluation. If I had not used this form of evaluation I would not have heard

> the varied concerns and questions of participants, sponsors, and other interested parties. Since classical evaluators believe in an 'objective truth' equally relevant to all parties, their studies rarely acknowledge the diversity of questions posed by different interest-groups. (Parlett & Hamilton 1972, p. 9)

I also sought an "objective truth" but one that acknowledged the diversity of teachers and their students. The purpose of my illuminative evaluation could not be measured in the way of much educational measurement today. Biesta writes,

> I have shown we now live in [an] age in which discussions about education are dominated by measurement and comparisons of educational outcomes and that these measurements as such seem to direct much of educational policy and, through this, also much of educational practice. The danger here is that we end up valuing what is measured, rather than that we engage in measurement of what we value. (2009, p. 43)

I measured the effectiveness of aSCuPTaS as a communicator of what a 'good' primary science education might be by 'candlepower'—a unit of the past used to measure light intensity. One candlepower equalled the light emitted by a candle of specific size. The candlepower developing as the teachers of 'Imagined' wrote the words of their planning and spoke the words of their practice left me with an abiding sense of possibility and sustainability and a belief that aSCuPTaS was speaking in a way that had lowered the barriers of primary teachers' resistance to teaching science. I will always remember the role of the 'bible' and the gift of responsibility in kindling the light of science to shine in the hearts and minds of primary teachers. Together I believe they gave the primary teachers I worked with more certainty that they could trust their heart of teaching when bringing science into their practice.

These experiences did not come without some frustration for me, or a slight degree of resentment from the teachers. My love and pride in aSCuPTaS was similar in many ways to the 'love' of subject that Palmer (1983/93) speaks of and I had to quieten my need to control as the teachers of 'Imagined' began to work with aSCuPTaS. I had to realise I was working with confident and capable people who knew what would make aSCuPTaS live. Their resentment came from the after-school commitment they needed to make and my need for them to record their plans. These differences were forgotten as soon as they became immersed in their planning and their ideas began to shine in the faces of their students.

There are a visible and tangible flows of energy to be seen in the text of this chapter that provide my evidence that the words of aSCuPTaS might bring energy from a curriculum-developer to primary teachers. I might have captured more completely the illumination of aSCuPTaS in terms of the flow of energy from teachers to their children with the multi-media approach of Whitehead (2009). It might have added another dimension—such multimedia representation could have brought the energy of the final performance of conductor and orchestra to be measured by an audience. Rather, my intentionality was to bring "more than I contain[ed]" into words and ideas so that I might elicit "more" than those words and ideas from "inside" the minds of other teachers in ways that let light into their thoughts about science, and prevail upon teachers to think about their responsibility, to give it expression, to communicate it in words and in ethical fashion (Todd, 2001, p. 438).

I leave this chapter with thoughts of the differences between the children/students whom primary and secondary teachers work with. The youthfulness and innocence of the very young children primary teachers have in their classes might help them feel more responsible for their children's nurturing than those who teach beyond primary school. I believe older students and adults, who no longer visibly display their kitten-like vulnerability and eagerness, are often like children when invited to learn something new. I believe they also need to be treated with the pedagogic tact often seen as the domain of primary teachers no matter what the age of those who learn. This notion of responsibility for the minds and hearts of all learners in their vulnerability raises questions about who we ask to teach and how as teachers we might remain conscious of our purpose in teaching—one that includes socialisation, individuation and qualification (Biesta, 2009). How we might achieve this is beyond the realms of my inquiry.

CHAPTER 6

BRINGING THE LIGHT OF SCIENCE TO SHINE

Anthem

Ring the bells that still can ring
Forget your perfect offering
There is a crack, a crack in everything
That's how the light gets in.
Leonard Cohen (n.d.)

I leave my inquiry knowing I have "left something rather than nothing when confronted by the suffering of another" (Chinnery, 2017). My inquiry emerged from the conflicts I anticipated might result from the value I place on science teaching's increasing prominence in Australian primary schools and the tensions this might cause for general primary teachers because I believed they should be responsible for this science teaching and the worth this could bring.

The 'something' of my imaginations is an offering sourced from my own experiences as a teacher. It is a science curriculum for primary teachers and their students, aSCuPTaS. My need to do something compelled me to take this journey of inquiry and take responsibility for exploring how the written words of a curriculum might play a part in removing some of the barriers that might make some Australian primary teachers reluctant to take responsibility for science teaching.

My methods are those of a living inquiry in the developmental way of Whitehead (1985) who has continued to refine, extend and justify this practice (2008, 2009). I believe these methods and the principles of my teaching practice have resulted in my ideas for a primary science curriculum possibly straying from those of others whose work relates to this area.

The first form of aSCuPTaS intuitively tumbled from my heart in the early years of my retirement, raw from my experiences of change in secondary school. It was my way of communicating with primary teachers the content and nuances of science teaching and learning that came from my experiences of change. But these words were those of an individual secondary teacher, the truth behind them and trust primary teachers could place in them was unsubstantiated—my inquiry has focussed on searching for their trustworthiness.

It has been a capricious journey, moving through time to a sea of memories, coming to understand these and the effects they brought to aSCuPTaS, but it is a journey that ultimately brought faith that aSCuPTaS represented more than a knee-jerk reaction of an exhausted teacher harbouring bittersweet memories of pleasure tinged with sadness. It was an offering that might bring hope for primary science teaching and the teachers called to do this—not a 'perfect' offering, but one with cracks that let light in (Cohen, n. d.), leaving openings for new ideas as we come to understand more—opportunities for resurrection

There is no obvious reason why aSCuPTaS should offer anything different from other science curricula and programs available to primary teachers in Australia. Its content is sourced from the *Statements of Learning for Science* (MCEETYA, 2006) and its focus on the development of a deep understanding of significant science concepts have been guided by Teaching for Understanding (www.pz.harvard.edu/projects). I eased pedagogical ideas into aSCuPTaS on the 'advice' of those who contributed to my growing understanding of pedagogy and some of the values Australia places on education published in the *Melbourne Declaration* (2008). Neither the science content, the pedagogy of aSCuPTaS or the focus on deep understanding was destined to bring many differences to aSCuPTaS—they are readily available to anyone. But I believe the methods I have used, my compassion and understanding for primary teachers introducing science into their curriculum, the freedoms I had as a curriculum-writer and traditions I brought to this inquiry have contributed to these differences and perhaps brought new perspectives to a science curriculum for primary teachers.

aSCuPTaS has become my way of speaking gently to generalist primary teachers of change. In this chapter, I consider the conditions of my curriculum- writing that have allowed these differences. aSCuPTaS has a strong purpose—to offer support and give primary teachers confidence as they make changes to science teaching and learning in their schools—a way that might bring the light of science to shine in the minds and hearts of primary teachers. I use Leonard Cohen's words about his song *Anthem* to describe my feelings for aSCuPTaS, not as a perfect offering but as an offering of hope.

> It's hard to do a com[m]entary in special for this particular song because it took ten years to write. There's not a line in it that I couldn't defend. There's not a line in the album that I can't defend, but this song especially. I delayed its birth for so long because it wasn't right or appropriate or true or it was too easy or the ideas were too fast or too fuss (sic), but the way it is now it deserves to be born. I've been playing this song for many years and I knew that I was on the track of a really good song. I knew it stood for something clear and strong in my own heart. And I despaired of ever getting it and I was playing it on Rebecca's synthesizer, and she said "That's perfect just like that" And I said "Really?" She said "Yeah let's go down to the studio now!" (Cohen, n.d.)

I believe aSCuPTaS is ready to be born and the ideas around its birth may add to our understanding of how a curriculum might contribute to transformations for change.

A CHILD OF FREEDOM AND FAITH

FREEDOM OF METHOD

In Chapter 2 I write of continuing concerns with primary school children's results falling on international testing programs, that many generalist primary teachers have little substantial science background and that many of Australia's science curricula are difficult to interpret for primary teachers (Rennie et al., 2001; Skilbeck & Connell, 2004; Dawson & Venville, 2006; Angus et al., 2007; Rennie & Goodrum, 2007; Tytler, 2007; ASTA, 2014; Lowe & Appleton, 2015; Fitzgerald & Smith, 2016; Thomson et al., 2012, 2016). I am not sure the *Australian Curriculum: Science* (ACARA, 2017) written from a consultative basis, will necessarily help alleviate the concerns about primary science teaching. Chris Berg (2014), a Research Fellow with the Institute of Public Affairs (Australia) writes "the national [Australian] curriculum is not really a national curriculum at all, but instead a blank slate onto which various education players can impose their own ideas". I wonder if this promotes freedom for primary teachers but I believe it might promote fear to a point when teachers experience burn-out. van Manen writes,

> Teacher burn-out is not necessarily a symptom of excessive output, of being overworked. It may be the condition that ensues when as teachers we no longer know why we are doing what we are doing. Teacher burn-out is hopeless in that nobody can make us believe there is an answer to the sigh, "What's the use?" (1990, p. 123)

My response to the concerns about science education in primary schools was to listen to the voices of primary teachers as I have shaped aSCuPTaS from my practice because of the mutual gains that might emerge. Perhaps my way has enabled me to reveal some of the principles of curriculum-writing emerging from my practice. van Manen writes,

> A mother, a father, a teacher who acts tactfully in the lives of children is a pedagogue. But only a person who can bring to speech (to consciousness) the logos of this pedagogic tactfulness is a theorist in a more profound sense.
>
> … To reconcile once again education with pedagogy requires that educational theory (curriculum and instructional thought) restores its original affiliation with that which grounds the pedagogic good. (1982, p. 47).

I believe that in many Australian primary schools the *Australian Curriculum: Science* (2017) will be translated into curricula based on teachers' practice. I have been in the fortunate position of having an opportunity to bring my thoughts to speech (van Manen, 1982, p. 47). To search for a curriculum that speaks directly with primary teachers, is attentive to their voices and the concerns they have when teaching science has been the focus of my inquiry. My purpose is not to be critical, and not to replace generalist primary teachers with science specialists. Rather it is to sow a sense of acting responsibly towards the science learning that I value in primary schools and return respect to primary teachers' ability to teach science and the gains that might come from rethinking a science curriculum for primary teachers.

My freedom to take a road less travelled and write a curriculum alone from my 'lived experiences' of teaching rather than work collaboratively in the way the *Australian Curriculum: Science* (ACARA, 2017) or in the traditional way based on the disciplines of philosophy, psychology, sociology and history of education (Whitehead, 2008). This way has perhaps enabled me to think pedagogically about the way a curriculum might interact with primary teachers and give me space to dwell on my journey and perhaps see more. Whitehead wrote about theories based on classic lines as ones that might make the mistake of "thinking that the disciplines of education, individually or in any combination, could explain adequately an individual's educational influence in their own learning and in the learning of others" (2008, p. 104).

FREEDOM TO SPEAK

Much of what I have written in this inquiry relates to communication—what I write of and my way of writing for primary teachers so they understand the messages about science they take to their students. I talk of my writing in aSCuPTaS as speaking because I find it more appropriate for the conversational nature of the writing I use. Primary and secondary teachers might share a profession but we come with our own individuality—our different characteristics resulting from the interplay of genetics and environment. In our personal lives we will be diverse—our origins, first language, religions, skin colour, interests, family and so forth—just like the children and students who come to our classes.

As teachers we have probably shared more things, such as, experiences of childhood and primary school—beginning to read, to write, to use numbers and words, to understand the world we live in and socialise. Some experiences have given us objective knowledge and others subjective knowledge—feelings of 'good' and feelings of 'bad'. Perhaps only a few of us have much memory of primary science. We might share interests, skills, aspects of our cognitive ability, experiences in secondary and tertiary education, experience as teachers, perhaps as parents and grandparents. Primary and secondary teachers who are older like me, have seen significant changes in the traditions of education. Maybe all we share about curriculum-development is what we came to understand in our teacher training and through our experiences of teaching.

But I know I do not share the pedagogical expertise of many primary teachers. I do not have their knowledge and understanding of how to plan and act in the moment to engage each of their students because they abide more closely with their children than is ever possible for secondary teachers. I know and admire this—only late in my career did I understand the good emanating from a greater focus on coming to understand my students and began to change my traditions. I also know I am unlikely to share with many of my primary colleagues my tertiary experience with science, my years of science teaching and my opportunity to immerse in hours of reflection on curriculum and notions of pedagogy.

It is these differences that encouraged me to adopt the role of curriculum-developer and create a reconceptualised curriculum that recognised the mutual gain that could emerge from this synergy of expertise—a blending of my understanding of science and developing understanding of pedagogy and the pedagogical strengths of primary teachers with the love and respect we share for the students who drop each year into our hands—love that can bring miracles when a space for miracles is made (Seidel & Jardine, 2014, p. 7). Together we might make miracles happen.

I would speak to generalist primary teachers of science knowledge, of the purpose and values that might come from science teaching in primary schools, of the important roles they can play, of aspects of pedagogy and of opportunities to learn. I would leave primary teachers responsibility to choose the ways they would share this science with their students that are appropriate for them and their students in the environments where they teach and learn together.

I ask why I spoke with generalist primary teachers. I answer, because they are there and they have opportunities I found missing when teaching in early secondary school. They teach across the curriculum and can make invaluable links between science and other disciplines when moments arise, they are there to teach generic skills that cross disciplinary boundaries and there to answer the big questions that students inevitably begin to ask—questions that require input from many disciplines before even the beginnings of answers can grow. And primary teachers have a home that I so much desired when I began to change my teaching practice. Meyer writes,

> Place is where we go, where we find ourselves, and where we live and 'belong'. It is the background and context of our memories—a house, a neighborhood, a city, or some part of the world where we've travelled. Place concerns home, as well as displacement and exile. In the book, *Altogether Elsewhere*, Edward Said writes about exile and home: "Exile is strangely compelling to think about but terrible to experience. It is the unhealable rift forced between a human being and a native place, between the self and its true home: its essential sadness can never be surmounted". (1994, p. 137)

Whilst there is a practical sense of a home where teachers can be who they are with their children, I take the opportunity to talk of 'home' in a different sense. I find the native place of primary teachers exists in their pedagogical competence, its source not completely known, but for many, the idea of introducing science was to take them to a place of exile where they found few links to their home of literacy and numeracy and nurturing. aSCuPTaS may be the line that tethers primary teachers from the 'home they know' to their 'home of exile'—science. This is the antithesis of my experiences as a secondary science teacher—my home was science, my exile was my lack of pedagogical competence. I had to cast many lines before being able to reconcile the two.

The differences aSCuPTaS has with other curriculum originated in the gut feelings I brought to its first writing as PaSCuPTaS—their source the feelings I felt as a teacher in the latter part of my career, tossing and turning on turbulent waters, wallowing with no sense of place, no sign of horizons, no measure of comparison (Mabille, 2014, Gadamer, 1975/2004). aSCuPTaS grew from my need of explicit direction for a pedagogy of inclusion, invitation and communication but I leave this space quite empty in the journey I have planned for primary teachers. As curriculum-developer I may leave this space of pedagogy in the hands of primary teachers, but there is another space filled with different words and different ways of speaking because I see a need for teaching of another kind that requires the input of my developing pedagogical competence. This space is that of science. What I say in this space is not because I believe that science is beyond the capacity of the teachers I speak to but because many have not had opportunities to come to understand the meaning of the words. I hope my words in aSCuPTaS might bring a gently 'educative curriculum', a term that has been used by others (Davis, Sullivan Palincsar, Arias, Schultz Bismack, Marulis & Iwashyna, 2014; Davis & Krajcik, 2005).

I heard from primary teachers about the limited time available for science teaching, the lack of facilities and resources and the absence of support and a science background, which for some had made them lose confidence to teach science (see Chapter 2). I questioned how I might do this, unleashed myself from perceptions of current curriculum trends, allowed myself to reconceptualise a curriculum for primary science—my curriculum-writing took on a pedagogical role to allow a place for feelings.

Whilst my pedagogical sense urged me to be explicit, gentle and encouraging about the nature of science, I was uneasy about writing explicitly—it was contrary to the nature of curricula in Australia. Dewey (1938) helped me understand that writing in this way was not to remove freedom from primary teachers but to give them greater freedom to be with their children as they lure them into the intricate web and wonders of science (see Chapter 3) and to reduce the time spent on preparation and the time necessary to complete each science unit using pedagogy that comes from the core of their heart and the call of their students (see Chapter 4). My context may be different, but my actions echoed Dewey's thoughts despite the lapse in time.

> many of the newer schools tend to make little or nothing of organized subject-matter of study; to proceed as if any form of direction and guidance by adults were an invasion of individual freedom, and as if the idea that education should be concerned with the present and future meant that acquaintance with the past has little or no role to play in education. (1938, p.7)

In aSCuPTaS there are questions to ask and stories of a 'biblical' nature to read, but there are no demanding "objectives, aims, teacher expectations, intended learning outcomes, goals or ends in view … a language of hope out of which hope itself has been systematically purged" (van Manen, 1990, p. 122). It includes no summative assessment, no standardised testing programs that slot children into categories too easily and crush their hopes with the weight of a 'D' not an 'A' for a future—before they have had a chance to know and to be who they are. 1990 is a long time ago and I am not sure much has changed other than in the small oases primary teachers create, "right in the midst of the often-debilitating contemporary circumstances of schools" (Seidel & Jardine, 2014, p. 4). aSCuPTaS is different, it has been written for primary teachers, their needs, their students, their community. It is not a 'one-size fits all' curriculum nor is it a program, a recipe for science learning. aSCuPTaS offers guidance that might lead to freedom and emerges from the freedom I have had as a curriculum-maker.

I am sure I am not alone in my visions for primary science teaching, but aSCuPTaS is different because of the freedoms I enjoyed. The freedom I experienced as curriculum-writer permitted expression of my changing traditions of science teaching and learning without the constraints often placed on curriculum-writers—constraints imposed by "the institutional and personal and cultural and economic and political things that distort and demean our work, [that] rise up again and again" (Seidel & Jardine, 2014, p.189), constraints that come from writers themselves and their traditions and constraints emanating from traditions grown around science teaching, science curricula and the purposes of science teaching in primary schools. My work cannot be touched because my work lives, at least for a time in a space of stillness and freedom.

aSCuPTaS is different because I have focussed on opening the minds of primary teachers to have faith in their ability to teach science—not by creating new horizons of knowing more about science as some might say but to create a horizon of confidence that they can teach science. It is different because I presumed a purpose for aSCuPTaS that differs from the purpose of others who write science curricula or speak of ways to bring more consistent science learning to primary schools. It was a purpose that grew from my understanding of primary teachers, my involvement with primary students coming to their first years in secondary schools and what I was beginning to hear about the suggested ways of improving science learning in primary schools. It comes from my changing views of science in primary schools and early secondary or middle schools from Years 5-8.

I came to understand that the purpose of science in primary schools is about cultivating the inquisitive nature of younger students by placing greater emphasis on the wonder of, connection with and applications of the world of science we live in and from this would flow a modicum or more of significant science understanding. Who better than generalist primary teachers to bring this science world to life and help their children understand there is more to science than learning facts and wearing 'lab coats and safety goggles'.

Taking a path of loneliness when writing aSCuPTaS brought more opportunities than if I had partaken in a collaborative curriculum-development like that used in The *Australian Curriculum: Science* (ACARA, 2017) (see Chapter 2). It gave me freedom to trust and follow my inner feelings and traditions which may have got lost in a collaborative approach or may have led to an unwieldy, undefined curriculum because everyone's views and ideas are accommodated.

There are other freedoms I enjoyed as I wrote aSCuPTaS. Bonnie Litowitz (2014) writes of communication,

> I have tried to show how the unique properties of language provide the necessary conditions for both our individual identity (our subjectivity) and our intersubjective encounters with others. The uniqueness of the acquisition of the same language system for each of us, plus the limited sloppiness of this perfectly imperfect system as it has evolved, ensures that we must keep communicating if we are to maintain a sense both of self and of belonging. (p. 309)

These words helped me understand that the language I used in aSCuPTaS was one of conversation, not heavily laden with science but one more accessible to primary teachers, a language of words that became for some of the teachers who used aSCuPTaS, their 'bible'. My freedom gave me the opportunities to use my aesthetic sense to make aSCuPTaS more inviting, not a work of art but a resource that might encourage browsing.

The differences between aSCuPTaS and other curricula come from my freedom to remain attentive to the needs some primary teachers have when teaching science but its writing comes from the responsibility I felt as curriculum-writer—I knew what it was like to be tossed around on an open sea, of 'being' in a world of change for teachers. Once aSCuPTaS was completed I left it in the capable hands of primary teachers because I know they know and understand the nature of their students and how to engage them with science using the facilities available. I had my faith in them confirmed through the interactions of which I write in Chapter 5.

POSSIBILITIES FOR FIDELITY

The freedoms I have spoken of permitted my expression of truths I found from my teaching in aSCuPTaS. I believed it to be well grounded, but essentially it emerged from one heart, mine, and I have broken tradition with what has become the Australian way of curriculum-writing, a way that frequently involves collaboration and consultation. aSCuPTaS initially relied on descriptions and interpretations of my own experiences—what I have seen and heard and read and the sense I had made of changes and the effects these have had on my traditions.

I ask about fidelity and quote from Palmer (1983/93) wo has had a strong influence on my understanding of truth.

> The bond of listening holds the cosmic community together — careful, vulnerable listening for how things look from this standpoint and that, a listening that allows us not only to know the other but to be known from the other's point of view. (p. 97)

I have faith the initial truth of aSCuPTaS came from my "careful, vulnerable listening" to secondary and primary teachers. But, I remained both humble and wary—I was one, the audience for whom I had written many. As van Manen (2002) writes,

> Admittedly, as human science researchers, we should be modest in claiming special status for our insights. In point of fact, all phenomenological inquiry is cognizant of the realization that no interpretation is ever complete, no explication of meaning is ever final no insight is beyond challenge. (2002, p. 7)

For aSCuPTaS to be successful, it depended on trust—the trust I had in primary teachers and their reciprocated trust in aSCuPTaS. That it was worthy of trust began with the faith I developed in my interpretation of my own experiences with teaching (Chapters 3 and 4) and the understanding I developed through personal contact with primary teachers, some background about science teaching in Australian schools and later, my collecting of words primary teachers have spoken about what it means to be a primary teacher (Chapter 2). But I believe it was the response of a small group of teachers who used aSCuPTaS (Chapter 5) and the guidance of scholars and teachers from the past and present who have called me to delve more deeply into the feelings of my heart and the thoughts of my mind that increased my faith in the potential aSCuPTaS has to speak truthfully to primary teachers from a base of integrity and honesty.

Until I worked with the teachers of 'Imagined' fragments of my science background remained. Imbued in the scientific method, I continued to question the subjectivity and personal opinions of the methods used to write aSCuPTaS and the validity of my research since I am unqualified as a primary teacher, a curriculum-writer or as a researcher. And yet, I wanted aSCuPTaS to be valid because I believed that if it could speak to primary teachers it might bring 'good' to them and their students and to the teaching of science in their schools.

These notions of what this 'good' might look like were initially mine, but when I had the opportunity to undertake an illuminative evaluation (Parlett & Hamilton, 1972) I found a way to see aSCuPTaS in action through the eyes of those I wrote for—primary teachers, my audience, those who I hoped would translate and interpret the curriculum to bring 'good'. To work in this way helped me understand and appreciate the special qualities of primary teachers and dispel the myths that had lurked in the back of my mind. It was an opportunity to find if I was I wrong in assuming their ability to teach science, in recognising their pedagogical strengths and tact and having faith in their ability to create a 'space' for learning science as described by Palmer (1983/93, p. 71)—a space of "openness, boundaries, and an air of hospitality". It was an opportunity to see if I was wrong to write a curriculum that created boundaries and was explicit.

Illuminative evaluation gave me a chance to hear aSCuPTaS speaking. For the first time I heard the intersubjective qualities of the language I had used in writing, qualities that took aSCuPTaS beyond the solipsistic individual experience which might have dominated my inquiry to the reality of a psychological relation between people—primary teachers, their students and a curriculum-maker that emphasised our inherently social being. Litowitz (2014) writes,

> When we ask our patients to communicate freely we are asking them to relinquish their fantasy of perfect understanding, to have faith in processes of communication. We are asking them to engage with us in building joint referents, in parsing out feeling states and appeals for what we want (wish for, need, demand) from others, and they from us. These are the processes that they (and we) have been born into, but, somewhere along the line, have lost faith in. We ask them to stay with us despite our inevitable misinterpretations and the imperfections of the process. All our interventions are aimed at restoring that faith, however this might be described by our various theories. (p. 309)

Although the players in my scenario are different, the interventions I made through aSCuPTaS were designed to build joint points of reference about what we, as the three players, see as good for each of us when it comes to teaching and learning about science. But to establish these referents required a language, a mode of communication that enabled us to understand each other in this three-way community. In this scenario I have needed to listen, to hear, to act and to repeat this process over and over again until each player could recognise they had become part of a community of truth (Palmer, 1983/93, pp. 54-60), a community based on trust and faith in the actions and responses that move between us.

I watched the trust developing as I worked with the teachers of 'Imagined'. I asked what it is about aSCuPTaS that might have helped spawn this trust. Although my initial empathy was for the 'suffering' of primary teachers as they often struggled to include more science in their curriculum, my understanding of why they struggled grew when I returned to my own experiences as a teacher in a period of extensive change. I believe my interpretation of these 'lived experiences' and the freedom I had to write aSCuPTaS in a way that recognised the truth that might be behind primary teachers' reluctance to teach science helped develop the feeling of a shared responsibility for science teaching. I felt the trust increasing when I acknowledged that science is an addition to their curriculum that might seem difficult to accommodate, when I understood primary teachers wanted to know what science to teach and when I showed my faith in their capacity to take responsibility for teaching. I believe each contributed to this trust in the school of 'Imagined.

I believe aSCuPTaS with its boldly explicit descriptions of what to teach, its guidance about the opportunities primary teachers might provide for their students and acknowledgement that at most there might only be 90-120 minutes each week or perhaps every two out of three weeks was sufficient to set these teachers free and write some wonderful science experiences for their students—experiences unique and engaging and focussed on science. The 'good' I sought through aSCuPTaS appeared when the light of science began to shine in the hearts and minds of the teachers at 'Imagined'—the trustworthiness of aSCuPTaS appeared when 'they began to talk of science' in the same way 'I began to talk of we' as I grew more pedagogically aware of what it means to teach.

A QUICKENING OF ANTICIPATION

Inquiring into the emergence of aSCuPTaS has given me a way of exploring the effects of educational change on teachers by returning to the 'lived experiences' of teaching and change. It has given me a way to contemplate the actions being taken to implement change and to question if they are responsible, ethical, truthful and bring greater 'good' to those involved or if there might be better ways to bring about change—irresponsible actions might lead to teachers' distress. My inquiry has raised my perception of the role a curriculum might play to support primary teachers to take more responsibility for science learning. aSCuPTaS is this curriculum, a science curriculum I have written for primary teachers, whilst being conscious of my pedagogical responsibilities and the contributions that both curriculum-writers and teachers contribute to the curriculum students receive.

Of course aSCuPTaS is based on the needs of the times and must continually evolve—it is not immune and is already in need of changes that relate to the developing middle years' concept, the changing focuses of teacher education and the ever-changing advancement of technology and the effects it might have on teachers and teaching. aSCuPTaS is not a "perfect offering" (Cohen, n.d.)—there will always be multiple cracks that await new light to shine in. As curriculum-writer I have found each breath, each word, each touch can bring new meaning, ideas, experiences, thoughts and feelings, new connections and new anticipations—a web of greater wisdom waiting to be explored. But l hope to have trodden carefully and thoughtfully, so not to be caught in a web that might bring ill to the teachers I write for and students they work with.

I speak of a lonely journey but it was the way I kept my mind uncluttered by distractions as I searched for truth in my inquiry. In reality it has not been lonely as Jardine writes,

> My strength, my power, my potency, is also my weakness, and only in recognition of this lacuna comes the possibility of the cultivation of humility, of real humanity. That I construct the world only in light of my own experiences names my terrible loneliness and frailty and vulnerability and dependence. (2005, p. 50)

I apply Jardine's words to my role as a curriculum- maker. My experiences may have helped shape aSCuPTaS but without the influence of many, many others it would be less rich, less informed and less truthful. I can say with more confidence now that my inquiry is not based on a solipsistic individual experience—it comes from the work of many. My role has been to disentangle the threads that have sprung from different minds into a cloth that can be used by many, a cloth woven on a loom of fidelity.

aSCuPTaS is finished now. I feel a slight fluttering, a quickening of anticipation when I think of the possibilities that I saw as aSCuPTaS came alive in the hands of teachers in a Year 1-4 school and I watched their confidence increase. I can anticipate the 'good' it might bring to future primary teachers through teacher education and the development of curriculum support materials. I am beginning to see possibilities of how aSCuPTaS might have roles beyond the classroom. Whilst teachers in my illuminative evaluation responded positively to aSCuPTaS because it helped them understand the science they would be teaching, they sometimes found it difficult to embark on the planning process, they needed prompting and encouragement—a pedagogical hand. I have found there are limitations to my original belief that aSCuPTaS might speak to primary teachers without a human interpreter, which is often the way it might be in many Australian primary schools. It could go some way to achieving this and therefore have relevance to those already teaching, but a better result might be realised if the content of aSCuPTaS is introduced to teachers during their pre-service training—to give them opportunities to work with the materials before they are launched into classrooms.

Appleton supported a similar idea,

> Consequently, pre-service teacher education science subjects should include prospective teachers doing the science that they might be expected to teach, and helping them understand why the science they are doing "works" in both scientific and pedagogical senses. (2003, p. 19)

This idea of enabling primary teachers in training to learn about science in a way they can use in their practice is appealing, to learn by engaging with the science their students will learn. Not science as a 'greater knowledge of science' in the way it is sometimes conceived. Rather, as science connected to the way primary teachers will use it in their practice.

Although I began my inquiry believing the form aSCuPTaS takes might be used by primary teachers from Foundation to Year 6 and might be different in a number of ways from a science curriculum for secondary teachers, I leave it believing its format is equally applicable in Years 7 and 8—the point where I made my first exploration into curriculum.

Through my inquiry I have not only come to understand more about primary teachers and curriculum-writing but more about myself and who I am as a teacher and the significance this has for teachers. In the actions I have described taking place in my classroom I find how much my way of teaching echoes 'me', it is rarely loud or boisterous, frequently involves creative arts and makes reference to the natural environment and would rarely be called 'fun'—I cannot pretend to be someone else and remain truthful to myself. But, I must be careful that my personality and interests do not leave some students feeling unable to be lured into the intricate web of science or be invited into the circle of science learning (see Chapter 3). I ask where this latent understanding has come from—it has not always been part of my conscious behaviour as a teacher although I believe it hovered somewhere in my sub-consciousness. And yet I feel the 'good' this consciousness might give to anyone with pedagogical responsibility, anyone in a position to teach. Should it too become a greater focus in teacher education?

So many possibilities, so much hope for the future of science teaching and learning in primary schools, so much inquiry yet to take place.

MEMORANDUM — WHAT I LEAVE BEHIND

By writing my inquiry I hope to have shared a possible way of transforming a science curriculum for primary teachers from an object that is inaccessible, untranslatable and perhaps shackling to one that is supportive, encouraging and emancipating for many primary teachers. van Manen (1990) writes,

> The children may be there as objects of our human science interest in them—but they are often not concretely and morally present in that they force us to reflect on how we should talk and act with them and how we should live by their side. (p. 139)

I have paraphrased van Manen's words above to become, teachers may be there as objects of my human science interest and hope they have been concretely and morally present throughout my reflections, so that as curriculum-developer I could listen and act with them and together we can live side by side as we share the wonders of science with children.

To give primary teachers confidence to teach science to their students and understand the important role they can play has taken me on my journey to find aSCuPTaS—a curriculum designed for them. It is given in the hope that it might be an offering to primary teachers that could help break the resistance to science teaching and possible suffering some experience, and bring the light of science to shine in their minds and hearts. I offer aSCuPTaS as,

> part of my work of teaching, to cast a tale where no one is damaged by living in worlds of words, ideas, images, apprehensions and joys that are partly beyond his or her ken, but hopefully, no one is left quite the same. (Jardine, 2014, p. 59)

My writing of aSCuPTaS hopefully stresses, like Whitehead has written in relation to a different situation, "the importance of clarifying and communicating the values that carry hope for the flourishing of humanity in explanations of educational influence from self-study researchers" (2014, p. 81).

I leave behind *A Science Curriculum for Primary Teachers and their Students* and my living theory of why aSCuPTaS looks and reads the way it does because of the compassion, responsibility and faith that have accompanied me on this journey. But I also leave behind possibilities for further inquiry. Inquiry that can explore beyond the scope of my reflections to bring further insights into what it means to teach primary science and what it was about aSCuPTaS that might have encouraged the teachers of the 'Imagined' school to become more willing and confident, trust the guidance of aSCuPTaS and see science teaching differently.

The teachers I worked with are scattered now. They have chosen to move to different schools, to focus on bringing up their families, to start new careers or to explore the opportunities that retirement brings. Whilst my 'group of eight' teachers may have moved on, there are many teachers who might appreciate a chance to work with a curriculum such as aSCuPTaS and my hope is that other teachers and researchers might pluck aSCuPTaS from the shelf and use it personally or for further inquiry. Through their formal and informal reflections as they use aSCuPTaS and by asking the question that was raised by Jack Whitehead, "How do I improve my practice?" (Whitehead, 1989, p. 41) they too will be contributing "something rather than nothing" (Chinnery, 2017). and adding to the rich tapestry of understanding that is emerging through the development of living educational theory (Whitehead, 1989), particularly the possibilities a well defined curriculum, built on the basis of compassion, responsibility and faith could bring for primary teachers and science education.

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APPENDIX

A SCIENCE CURRICULUM for PRIMARY TEACHERS and their STUDENTS

The IMAGINED SCHOOL
YEARS 1-4

A curriculum designed to
'Kindle the light of science to shine in the hearts and minds of primary teachers and their students'

By Barbara Tassell

NOTES TO THE READER

I hope *A Science Curriculum for Primary Teachers and their Students*, **aSCuPTaS**, encourages and brings energy to primary teachers that helps them feel confident to take responsibility for science teaching from pre-Year 1 to Year 6. In this section you will find **aSCuPTaS** for Years 1-4 which I have trialled in the school 'Imagined'. To provide an overall view I have included the sequence of topics from Foundation to Year 6. For the 'Imagined' school of my inquiry I made slight adjustments because of the absence of a Foundation Year.

aSCuPTaS is a work in progress—not, as Leonard Cohen sings, a "perfect offering". Each time I look at it, I see improvements I could make to my ways of communicating ideas in both the Understanding Goals and the Background Information, but have made few changes so that it remains truthful to the form it was in when I introduced **aSCuPTaS** to the teachers of the 'Imagined' school. Its rationale is the essence of my PhD thesis, *Circles of truth in curriculum-making for science in the primary classroom: Keeping in mind simplicity, compassion and the 'faded green textbook'*. It is more about communication, compassion and pedagogy than it is about science content and is addressed to teachers. My focus has been on the words written for teachers to use as they plan and write unique units for their children and I have simplified much of the preliminary detail included before the trial as it seemed irrelevant for teachers. I often substitute children for students when I talk directly to teachers—this is the way I found they spoke of those in their care.

An important aspect of **aSCuPTaS** is that it has grown from the notion of trust—trust I hope has developed between me as curriculum-maker, the teachers who use **aSCuPTaS** and the students who learn science from them. I trust primary teachers to bring my words to life for those they teach. They must trust my words have been written in a way that is truthful to my understanding of a 'good' science education for the future of our children and my compassion for and understanding of those who teach them. I had hoped aSCuPTaS might be helpful to practising teachers without the intervention of mentors, but I believe more value can be gained from the dynamic situation that might develop between a mentor and small groups of teachers, either in pre-teaching courses or through professional learning opportunities.

FOR THOSE BENEATH OUR WINGS

Hidden in the folds of aSCuPTaS
Is ‘the faded green textbook’
Of science.
Its ideas and methods—the
Responsibilities that humans must take.

Hidden in the folds of aSCuPTaS
Are communication, STEM and STEAM
The arts of drama and dance
Of ink and paint—lines that bring
The words and ideas of science
To kindle the light of science to shine
In the hearts of those who touch her.

Hidden in the folds of aSCuPTaS
Are the teachers who bring it to life
Who show students and parents
The responsibility they take for
Creation, compassion, and pedagogy
In a community of trust.
For to teach is to learn and
To kindle the light of science in
Those who teach.

Hidden in the folds of aSCuPTas
Are the circles of curriculum-making that brought
Truth to the words of the
Maker, the teachers and their children
Of the wonders and humanity of science
And what it means to teach
And take responsibility
For those beneath our wings.

ACKNOWLEDGEMENTS

There are many who influenced the writing of **aSCuPTaS**. I would like to acknowledge the writers of the Australian produced *Statements of Learning for Science,* whose work from 2007 has guided the science content of of my curriculum, and those who have contributed to the Teaching for Understanding project. Their work in this project has made me think about teaching, what it means and how ideas need to be clearly communicated. I thank too my supervisor from Curtin University who urged me to uncover the reasons that drove me to design a science curriculum for primary teachers and why it might be different from one for secondary teachers.

I would like to thank the many students and colleagues who have contributed the rich tapestry of my teaching experiences and my family, especially my young grandchildren, who constantly remind me of the need for nurture and opportunity in the early years of education. A special thank you must go to my granddaughter Olivia and her friends at the Rainbow Childcare Centre whose work has been collected by Billie, one of their educators, to illustrate aSCuPTaS.

Finally, I thank in anticipation, the teachers who might use **aSCuPTaS** to 'kindle the light of science to shine in the hearts and minds of their children'.

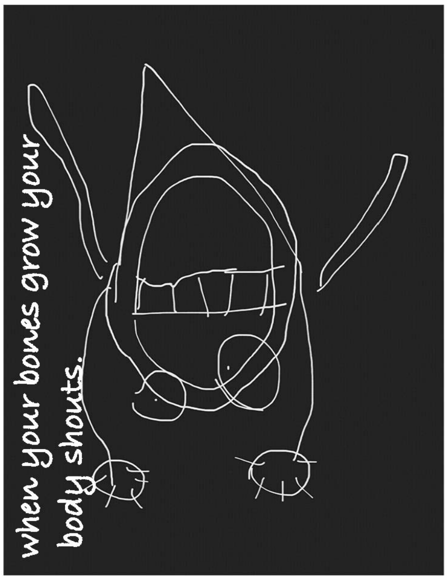
When a family wants a baby they have a meeting.

Worms used to have legs once upon a time.

Echidnas are only friendly if your heart is kind.

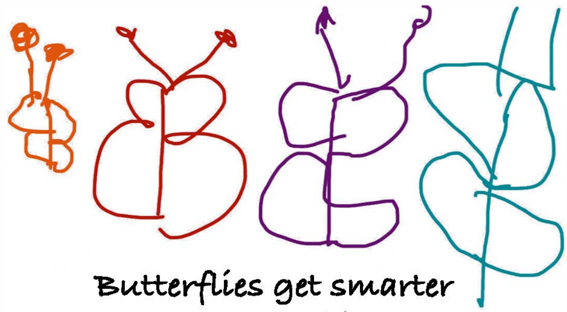
A bird can't sleep. It's eyes never stop seeing sky.

Only ants know the way home.

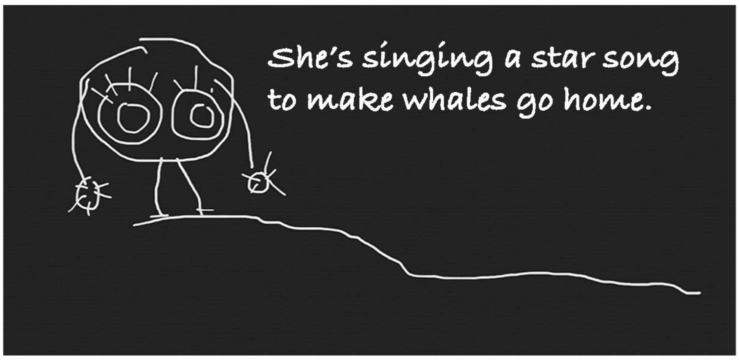


Every time I smile I feel my eyes changing colour.

It's one bubble machine that blows a hundred bubbles.



Butterflies get smarter when they get bigger.



When you die, your body goes into the leaves and they are saying hello to the old people who died..

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A NOTE TO SCHOOL PLANNERS

There are many ways those of you who take responsibility for overall planning in your school can support science teaching.

I ask you to support your teachers to make a dedicated time for science teaching each week. Each unit of work has been designed to be covered in a time equivalent to 9-12 hours, perhaps 6/7 afternoons each term. This allows room for the interruptions that happen in all primary schools and gives teachers a chance to take advantage of unplanned opportunities that arise.

Although I have written the content of aSCuPTaS to unfold in a sequential way, it can be adjusted so the pathways suit your school, especially if you have composite classes. Support your teachers to find ways of doing this so that students do not repeat or miss topics—it will not always be possible

To learn about science, students need to be taught, and to teach is the life-blood of teachers and teaching. As a school planner, you can support science teaching by providing teachers with professional learning opportunities that extend their understanding of what it means to teach and the methods and techniques they can use to engage their students with science.

WORDS FOR TEACHERS

KINDLING THE LIGHT OF SCIENCE TO SHINE

As curriculum-writer I invite you to take your class on an exploration of a world that begins with ideas about science, but will lead to a wealth of wonderous connections. I ask you to take responsibility for writing the details of this journey, because you understand the children you teach, know what facilities are available in your school and the surrounding community, and you can make connections between science and the other disciplines of your curriculum. Your skills and abilities as a teacher will help breathe life into '*A science curriculum for primary teachers and their students*'—aSCuPTaS.

Your purpose as a primary teacher is to kindle the light of science to shine in the hearts and minds of your children. To do this I ask you to take responsibility for preparing activities that engage them with the questions written in each unit of **aSCuPTaS**—activities that go beyond the traditional methods of science teaching and introduce technology, engineering, the arts and mathematics (STEAM). I ask you to monitor your children's progress through formative assessment and to teach your class in community so that your children have opportunities to learn from each other and develop respect for the individuality each of us has. I ask a lot, but I ask because I respect your individuality and capacity to teach science in your way whilst remaining conscious and respectful of the purpose of science teaching in primary schools.

My purpose in writing aSCuPTaS has been to kindle the light of science to shine in your hearts. I have taken responsibility for removing some of the obstacles you might experience when asked to teach science. I have been mindful that you might have little time for science teaching in your often-crowded curriculum, you may have little background in science, your school may have few facilities for teaching science and support from science specialists might be minimal. I hope you find **aSCuPTaS** attentive to these possible needs. Teaching the science in **aSCuPTaS** does not require many hours each term, does not require university qualifications in science or specialised equipment. It requires **passion**, **creativity** and **pedagogical responsibility**.

From my own teaching experiences, I have developed five principles that underpin **aSCuPTaS**. The first two, and aspects of the third, I have taken responsibility for by embedding them in the structure of **aSCuPTas.** Those that remain are essentially your responsibility.

1. Science learning should focus on the development of a deep understanding of significant science concepts.
2. Science knowledge emerges most effectively from a disciplinary base but should encourage a holistic view of science.
3. All children need to be invited to explore the intricate web of science.
4. Assessment in the primary years of science should be predominantly formative, as students learn and demonstrate their understanding of science by having opportunities to communicate their ideas.
5. Science classrooms need space, for each child's individuality to be recognised, shared and harnessed within a community of learners where horizons grow from the familiar to ones more challenging.

SEQUENCE OF TOPICS

This sequence of topics is designed so that students are taken on a pathway that gradually unfolds the content of science in more detail and depth. For one reason or another it might not always be possible to follow this pathway exactly. What is more important for children in their primary years is that they have regular contact with science and come to understand the possibilities it can bring by becoming engaged with and excited by the science units you plan for them.

YEAR	LIVING THINGS	MATTER	EARTH AND SPACE	ENERGY AND FORCE
F	***Things on our Earth** *Sorting the things we see on Earth*	**Materials We Use** *Introducing materials we use in our lives and how we might group them.*	***Beyond our Earth** *Thinking about the Sun, the Moon and the stars*	***Energy We Use** *Exploring how we use energy to make things work.*
1	***Living Things** *Introducing the characteristics that make things alive, particularly how living things grow and change.*	**Materials For Keeping Dry*** *Investigating materials that are waterproof and how we use these materials.*	***Seasons and Their Effects** *Looking at how the seasons affect the living and non-living world.*	***Light** *Investigating the sources and role of the light in our lives.*
2	**Living Things Need a Home** *Exploring why plants and animals live in different places.*	**Materials for Keeping Warm*** *Exploring materials that are heat insulators and why we need these materials.*	**Night and Day** *Comparing night and day, what causes them and the impact they have on life on Earth.*	**Sound** *Exploring different sounds and how we hear them.*
3	**Living Things Move** *Exploring how and why living things move.*	**Materials Can Change** *Investigating the effects of temperature on materials.*	**Water and Soil** *Investigating the conditions on Earth necessary to support plant life.*	**Force and Movement** *Investigating the forces (pushes or pulls) that are needed to get things moving.*
4	**Living Things Reproduce** *Investigating why and how living things reproduce.*	**Materials used in Water** *Introducing the properties of materials used in objects found in water—floating and sinking, rusting.*	**Our Place in the Solar System** *Exploring the place of Earth in the Solar System and comparing Earth with other planets.*	**Frictional Force** *Exploring the effects of friction on movement.*
5	**Living Things Are Different** *Exploring microscopic life. Introducing the cell as the basic unit of life.*	**Burning Materials** *Investigating the flammability of materials.*	**Water in the World** *Investigating why water is such a valuable resource.*	**Electricity as an Energy Source** *Investigating electricity as a source of energy in our lives.*
6	**Living Things Interact** *Beginning to investigate the interactions within the living world and between the living and non-living world.*	**The Collective Properties of Materials** *Considering why particular materials have been chosen in the design of common items.*	**The Earth as a Material Source** *Looking at natural and processed materials and where they come from.*	**Levers and Pulleys** *Investigating how levers and pulleys can be used to reduce the force needed to make something move.*

For the 'Imagined' school of my inquiry, I combined ideas from the two vertical units marked * in the Sequence and Scope to accommodate the absence of a Foundation Year.

PLANNING A SCIENCE UNIT

To plan your science units I provide few guidelines, because you will find your own ways to design and record how you will teach the science of aSCuPTaS. I urge you take inspiration from the Internet, the many wonderful resources that have been written about science teaching and activities that you can do and the countless beautiful fictional and non-fictional books that have been written for children about science.

When you look at aSCuPTaS you will find the goals of each unit are written in three organising areas. Although I have not named these in each unit, they appear in the order below.

Science as a Human Responsibility introduces questions about the history of science, how we use science in our lives and what it means to act responsibly when using science. The questions often have strong associations with other disciplines.

Science as Knowledge engages students with the significant concepts of science. As they go through their schooling they will gradually add depth and detail to this understanding.

Science as a Way to Know includes collecting and communicating information in the traditional ways of the scientist but there is also scope for much broader opportunities.

Having these separate organisers helps the children you teach develop an encompassing understanding of science and I have brought them together in each topic of the Sequence and Scope.

Your responsibility is to ask the questions written in each unit, to be familiar with possible answers to these and to listen to your students' answers. Sometimes you will want to insert further questions or add explicit information. Your students will sometimes ask questions for which you have no answer—not to know answers is part of the vulnerability of being human, but it is your responsibility to avoid saying too much when you are uncertain. Acknowledge your imperfection, ask your students to help or to ask their parents and try to find possible answers yourself. This is a lesson we all must learn because as teachers we are not infallible, but should always seek ways to find the truth.

I remind you that your purpose is to kindle the light of science to shine in the hearts and minds of your students and to plan activities that will engage them and give you opportunities to introduce the questions in this unit. I remind you that you are the teacher and to teach science is as much about teaching as it is about science. I remind you that you know most of the science I am asking you to teach but you may not have had an opportunity to think about what it means. I remind you to relax and take the intensity out of science teaching so that you can enjoy the time you spend on science with your students.

Each unit you plan provides an opportunity for your students to explore a topic. I have used the Year 1 topic 'Light' in this example of how I might do this.

Investigating the sources and role of the light in our lives

In this example I follow my preliminary thoughts rather than providing a detailed plan. What you do might be quite different because you are different from me and the children in your class might be quite different than those I imagine. Before beginning planning I read through the questions to be asked in the unit and the Background Information. These provide the cues for the activities you might do in this unit.

I begin by creating an engaging title and will make a space on the wall for the work we do in this unit—I call it 'Oh dear, the lights are out'. I tend to focus on the ideas in Science as a Human Responsibility and Science as Knowledge when I begin to write a unit because both provide opportunities to connect with Science as a Way to Know. The questions I ask in Science as a Way to Know are often only suggestions because I know they fit the topic—you can substitute your own ideas.

Oh dear the lights are out!!

1. I think I shall begin with a conversation about camping and what happens when it becomes dark. We can talk about the sources of light we use when camping and how these are different than those we have at home. We can talk about the 'olden days' and what was used to light houses at night. The children can make a collage of a camping trip and then we can talk again about their pictures on the wall. I can ask some of the questions in this unit and perhaps I will read the Hans Christian Anderson story 'The

Little Match Girl'. It is a sad story but it could stimulate some discussion—I think my children are ready for it.

2. Next I am going to bring torches and batteries to the classroom so we can start some experimenting. I can begin with three small torches, one with a new battery, one with a dead battery and one with no battery. This will start a conversation and we can talk about needing a battery to make the torch produce the light and we can talk about what happens when the energy in the battery runs out. We will begin a 'test' and the students can make predictions about when the battery will stop working. I will prepare a chart to record these—after one hour, two hours, three hours etc. We can talk about needing the energy in the battery to make the torch work and we can plan who takes the torch home if the batteries are still working at home time. Perhaps we will set up two torches in our room, one with a cheap battery and one with a more expensive battery than the other. Perhaps we can play with some solar lights that get their energy from the Sun. We could leave them in the Sun all day and watch them glow when we take them into a dark space. We can see if they still glow the next morning after they have been in the dark all night. This might be a good time to start talking about how we feel when we run out of energy and where we get our energy from.

3. We can discuss what we do when the lights go out at home. How does it feel? What is the first thing we do? How do you find your way around your house in the dark? I think we might play 'Blind Man's Bluff' and perhaps we can try to identify things by their shape, their texture and their smell. We could plan an emergency kit—what might we keep in an emergency kit in case the lights go out at night? Everyone will have a story to tell about the time when the lights went out—perhaps we could write a communal story.

4. Mmmm...I'd better think about glow worms now and what it is like to be blind. Perhaps we could make some braille letters and see if we can guess what they are. I could talk about Helen Keller and I know there is a story written about her that would be suitable for my class. I wonder if I will have time to do any more. I could perhaps bring in some luminous 'glow sticks'. Oh yes, I must remember to keep asking the questions. Perhaps we could...

Hopefully these thoughts will stimulate your imagination as you plan for your class!

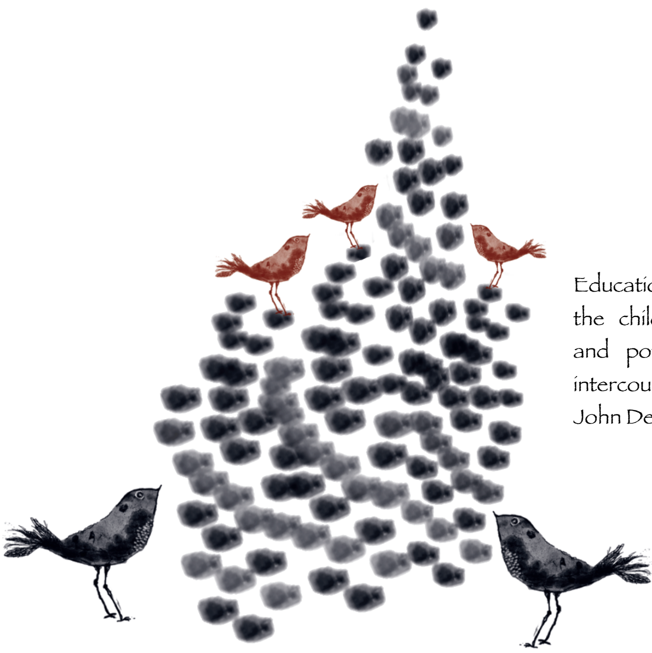
Remember

—To teach science in a community where you and your students can bring together a wealth of experience through the back and fro of dialogue as a class or in smaller groups. Dialogue will enrich your children's' understanding as they hear the valuable contributions that come from the collective knowledge of their peers.

—To invite all your students to interact with science by creating interesting activities that engage them, so that you have opportunities to work alongside individual students in need of your help. I encourage you to leave spaces of quiet where you and your students can renew your energy and think.

—To make science teaching a regular activity rather than to concentrate it into a whole day activity or as part of an integrated program because I have found neither does justice to learning about science.

—To expand the horizons of science. aSCuPTaS might stem from the discipline of science but it is your role to link science to what is happening in the other disciplines of your curriculum and the common skills that occur across the curriculum.



Education '...is the ability to see in the child's babblings the promise and potency of a future social intercourse and conversation...' John Dewey

OPPORTUNITIES TO GROW IN SCIENCE

An Annual Checklist

You may find this checklist useful to keep track of and think about the more universal and less science specific opportunities you can provide for your students as they learn about science. The list is flexible and needs to be personalised. In my list I include Howard Gardner and Benjamin Bloom, two people whose work influenced my own teaching. These names might not mean much to you and/or you may want to add the names and ideas of others who have inspired your teaching. I have written it in an abbreviated form that might make it difficult for you to interpret my exact meaning. These details are not my main purpose in sharing the list with you. It is the concept of providing students of all ages with a wide range of opportunities that I have found to be valuable.

If you check the opportunities you are giving your children as you write each science unit, it will be clear whether some areas need more, or perhaps less, attention.

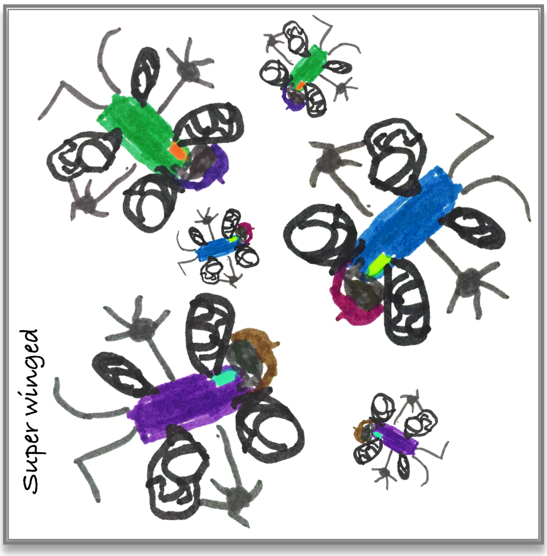
1. Have your children had the opportunity to use the intelligences described by Howard Gardner?	
Bodily/ Kinaesthetic—physically doing things	
Interpersonal—interacting with others	
Intrapersonal—reflecting on what you have done	
Verbal/Linguistic—using spoken and written words	
Mathematical/Logical—seeing patterns and working logically	
Musical/Rhythmic—using rhythm and music	
Visual/Spatial—designing and planning	
Naturalist—interacting with nature	

2. Have you provided opportunities for your children to practise using their minds at all levels of Bloom's Taxonomy?	
Remembering	
Understanding (Comprehending)	
Applying	
Analysing	
Evaluating	
Creating	
3. Have the children in your class had an opportunity to work in a variety of environments?	
Have they worked outside the classroom but still in the school—the library, playground, pool or gym?	
Have they worked outside the school—in the museum, zoo, on farms, in environment centres etc.?	
Have they interacted with members of the community either at school or outside— scientists, health or community project workers etc.?	
4. Have your children been given the opportunity to communicate in a variety of ways?	
• in writing	
• by the spoken word	
• through drama or dance	
• through art or photography	
• by using technology	

5. Have you provided opportunities for your children to find information from a range of sources?	
• from written sources	
• from internet resources	
• from people	
• through all their senses	
• by experimenting and testing	
6. Have you given your children opportunities to show they can persist? Have you	
• given them problem solving/open ended activities?	
• allowed them time to pursue these activities?	
7. Have you helped your children develop responsibility for their own learning? Have you given them opportunities to	
• set their own goals at any time in the unit?	
• to select where they will complete their work – for example, at their desk or in the reading area, outside or in the library?	
• choose how they would like to share their work with you or other students?	
8. Have you given your children the opportunity of being assessed by a variety of people?	
• by themselves (self-assessment)	
• by their peers	
• by you (the teacher)	

9. Have you offered your class opportunities to work in different situations?	
• individually	
• in pairs	
• in groups	
• in silence	
10. Have you provided opportunities for your children to share what they have learned?	
• with the class	
• with relatives	
• with the whole school	
• with the community	

SCIENCE as a WAY to KNOW



Scientists collect information from both primary and secondary sources

In their science education during Years 1 - 4 students will have opportunities to explore the following questions:

Primary sources — investigations

- What observations can I make? What senses will I use to make these observations? How can I record these observations?
- What measurements can I take? How will I take these measurements? How can I record my observations?
- What can I learn from this experiment? Can I identify the question being asked, predict what I think will happen and describe what I have found out? Can I follow instructions?
- Is this experiment a good experiment? Is it a fair test? Could I improve or change the experiment?

Secondary sources — written, visual, human and electronic sources

- Where has this information come from?
- Is this information reliable?
- What have I learned from this information?

Scientists communicate their ideas with other scientists and with the general population

In their science education from Year 1 - 4 students will have opportunities to consider the following questions:

- How can this information be organised—as a table, as a graph/chart or in another sort of visual organiser?
- Am I able to communicate this information—in words, in drawings, in photographs?
- Am I communicating in a way that suits the audience—the rest of the class, my family, the general community, scientists?
- Does my audience understand what I am communicating?

These questions are integrated into each of the topics described under the headings, 'Science as Knowledge'. Often you will not need to refer to them separately as you plan, but they give you an overall picture of the opportunities your children might experience in science.

SCIENCE as a HUMAN RESPONSIBILITY

Humans have always strived to find out about the world and have used this knowledge in their daily lives

In their science education during Years 1 - 4 students will have opportunities to explore the following questions:

- Why are we interested in finding out about this science?
- Who were the people who found out about this science?
- How do we use this science in our lives?
- Why should we use this science responsibly?
- Who are the people who work in science?
- What questions are humans unable to answer?

These questions are integrated into each of the topics described under the headings, 'Science as Knowledge'. Often you will not need to refer to them separately as you plan, but they give you an overall picture of the opportunities your children might experience in science.

SCIENCE as KNOWLEDGE
LIVING THINGS

Understanding of these ideas will grow through the primary years

- There are many different types of living things.
- Living things have characteristics that differentiate them from non-living things.
- Scientists group living things using their characteristics.
- Living things continually interact with non-living things

YEAR 1

LIVING THINGS

Introducing the characteristics of living things

Suggested Time: 9 - 12 hours

Understanding Goals

1. Students begin to understand how their lives interact with other living things.
   a. How do we rely on other living things?
   b. What are our responsibilities to other living things?

2. Students begin to understand which visible characteristics scientists use to classify the things in our world.
   a. What differences can we see between living and non-living things?
   b. What do all living things need? What happens when living things don't get what they need?
   c. What differences can we see between living things? How do living things vary in how they look and where they live?
   d. All living things can grow—what changes do we see as plants and animals grow?

3A. Students understand that scientists can collect information by making observations and measuring.
   a. What observations can we make to separate living from non-living things and plants from animals?
   b. What observations can be made about plant and animal growth? What instruments can be used to measure growth?

3B. Students understand that pictures and graphs can be used to communicate information about living things.
   a. What sort of information about living things can scientists record and communicate using pictures/photographs?

Background Information

Humans interact with other living things, both plants and animals. Humans use plants and animals as food sources and farmers 'grow' crops and animals for people. The animals that farmers keep are domestic animals. Because they can't roam, farmers make sure the animals have enough food and water in the fields where they are kept or hand-feed them. Farmers also have the responsibility of making sure their plants get what they need to grow. Plants don't need to be given food because they make their own, but they do need water and fertilizer. Pets are also domestic animals and we need to make sure they always have food and water. Living things in the wild are dependent on their needs being met by the environment where they live. If there is a drought or a bushfire plants die and the animals that depend on them have no food. These ideas are good starting points for discussions about the ethical question, 'What are our responsibilities to other living things?'

Scientists have grouped living things together because they have a special set of characteristics—things that all living things can do and things that all living things need. All living things grow, reproduce, produce wastes and respond to stimuli—you say 'ouch' if you step on a pin and some plants close their flowers when the Sun goes down at night. They all need a source of energy and a way of releasing this energy so it can be used—we call this process 'respiration'. Living things are made of cells and cell products and eventually die. Many of these characteristics are too complex to investigate by children of this age because they are not visible and/or measurable but they can understand that if living things don't get what they need they will die — if they don't get water they will die and if they don't get food they will die. The three most easily observed characteristics of living things are that they can grow, they can reproduce and they can move. Remember plants can move but are not mobile.

Although all living things share these characteristics, they are also very different from each other. Many of these differences visible. Differences that children recognise easily are where they live, how they look (size, shape, colours) and how they feel. It is because of the way that living things get their food (energy) that scientists have formed the two distinct groups of plants and animals. Animals need to be mobile (move around) so they can search for food but plants, because they can make their own food, don't need to be mobile (although they can move).

When living things grow they change and some of these changes are observable and measurable. Children often think of growth as being a change in height. As animals grow we can observe a number of changes—they get bulkier, they change shape, they may grow hair, fur or feathers. Using simple instruments we can measure changes such as height and mass. As plants grow we can measure their height and the size of the leaves, and count the number of leaves they have. It is hard to measure the mass of a plant—we would need to take it out of the ground and it would die. Even though all living things grow it doesn't mean they keep on increasing in height. Growth as a characteristic of living things includes the repair of tissues. Once living things reach an adult age they stop increasing their height but they can still grow new tissue. As humans we usually stop growing taller when we are about 20 years old, but we can grow more cells to replace those damaged by accident or by wear.

Non-living things may have some characteristics of living things, but not all. Non-living things can also be divided into categories—natural non-living things such as rocks and soil, and man-made non-living things such as buildings and cars.

To collect evidence, scientists make observations and record these. Students can make observations using sight to know if something is alive — can it grow, move or reproduce? Observations made without taking measurements (qualitative observations) may vary depending on who makes them—colours and size are often described differently. Visual observation can often be made with a camera or on film. Scientists like to collect more concrete evidence by measuring (quantitative observations). Measurements can be made in different ways. Counting is a form of measurement—we can count the legs on different animals, we can count the number of babies they have and we can count the number of leaves on a plant.

Once they have made observations scientists record their evidence in a way they can show it to other people. They often use drawings to share information about the structure of plants and animals and graphs to show how things change over time.

YEAR 2

LIVING THINGS NEED A HOME

Exploring the reasons why plants and animals live in different places

Suggested Time: 9 - 12 hours

Understanding Goals

1. Students begin to understand that human interference and natural disaster can destroy the places where plants and animals live.
    a. What events can destroy where plants and animals live?
    b. What can we do to help when the homes of plants and animals are destroyed?
    c. In what ways can humans act responsibly when they develop/use more land and take away the homes of plants and animals?

2. Students begin to understand that animals and plants need a place to live.
    a. What different types of places are there to live in?
    b. What do the living things need from the places they live in? Do plants and animals need the same things?
    c. Why do some animals build homes to live in? What do these homes look like? Do all animals build homes?

3A. Students begin to understand that scientists can collect and record information about the places plants and animals live.
    a. What information can be collected using a thermometer? What information can be collected using a rain gauge?
    b. How can books, people and the Internet help us find information about where plants and animals live?

3B. Students begin to understand that different types of information can be communicated in different ways.
    a. What sorts of information are best communicated using a chart or table?
    b. What sorts of information can be communicated using photographs and pictures?

Background Information

As humans we all have homes. Our homes provide us with shelter and we build them where we know we can get the things we need—food, oxygen and clean water. Our homes protect us from 'invasion' by other people or animals and from the weather. Fires, floods and storms sometimes damage people's homes. When this happens, we often get help from the community where we live and the government. Plants and animals don't get the same protection if their homes are damaged. Sometimes their homes can be damaged by natural disasters, but humans also cause damage as they build more houses, improve our road systems and take down forests for timber or to make more farmland. As humans we do these things to help our survival, but we should also be responsible and try to minimise the effect on plants and animals. This topic provides a good opportunity for students to begin discussing what humans can do to take responsibility for the environment as development occurs.

When students begin this topic, they will often think of animals, not plants, having 'homes'. They will usually relate a home to a structure such as a burrow or a nest rather than a home in the broader sense of a place to live. Living things live in all sorts of places. Some live in water—the sea, rivers, lakes and ponds. Some of the water is salty and some of the water is fresh. Other living things live on the land and some live partly on the land and in the water. Plants and animals can live in very cold places like the Arctic and Antarctic and in hot places around the equator. Many live at high altitudes.

Wherever they live they must be able to get what they need to survive. Plants must be able to get sunlight, carbon dioxide and water so they can make their own food and animals must be able to get food and water—almost all living things need oxygen. Animals and plants that live on land get oxygen from the air—anything living in water usually has a special way of getting oxygen from water. Fish have gills, which can do this—our lungs can't do this and we drown. Plants need light to survive. When you go deep down under the sea there are no plants because it is too dark. Similarly, plants don't grow in deep caves because of the lack of light.

Some animals build homes to protect themselves but others find 'ready-made' homes—under rocks, in hollow trees, in a drainpipe or even in our clothing. They need a home to protect themselves from other living things and from the elements. Birds often build nests in the trees to protect themselves from ground predators and rabbits build burrows underground, where they are safe from many of their predators. In hot places animals often make shelters under rocks to protect themselves from the Sun and in cold places animals build nests and burrows to keep them warm in cold weather.

When we look closely at the places animals and plants live there are many differences. There are obvious differences such as living on land or in saltwater or freshwater, but there are other less distinct differences in the climates they live in. Some prefer hot climates rather than cold climates. Many living things need to live where there is a high rainfall and others can survive in very dry climates. Scientists often monitor the climate where things live to find what conditions suit the different living things. They measure temperature, humidity, wind, rainfall and the length of time the Sun is out, to build up a picture of the environment where different things live. Children can practise making measurements using simple instruments such as thermometers and rain gauges, which they can make themselves. They can also use second-hand data from the weather bureau to look at rainfall, daily temperatures and daylight hours.

This unit also lends itself to students gathering information about different animals and plants from a variety of sources. It provides opportunities for students to go on excursions where they can gather information using different instruments and record this information using different methods— charts, tables, pictures, photographs. Charts and tables are often used to communicate information about measurements (quantitative information) whereas pictures and photographs are used to communicate non-measurable information (qualitative information).

YEAR 3
LIVING THINGS MOVE
Exploring how and why living things move

Suggested Time: 9 - 12 hours

Understanding Goals

1. Students begin to understand that humans use their knowledge of how we move to help those with movement disorders.
   a. Who do we go to if we have trouble moving? How can they help?
   b. What aids have been made to assist those who have difficulty moving?

2. Students begin to understand that plants and animals move to help them survive
   a. How does moving help plants and animals survive?
   b. What sorts of movements can plants and animals make?
   c. How are plant movements different to animal movements?
   d. What structures do animals have to help them move?

3A. Students begin to understand that scientists can collect information about plant and animal movement by experimenting.
   a. What questions can we answer by doing a particular experiment?
   b. Is this experiment a fair test? How will we collect information in this experiment?

3B. Students begin to understand that scientists can share information they collect through photography and drawings.
   a. Why is photography a good way of communicating information about movement?
   b. How can drawings be used to help communicate information about the way an experiment has been done?

Background Information

Movement is an important part of our lives. If we are injured and not able to move our lives are changed and we try to get moving again as soon as possible. As we understand more about the way we move, the treatments we receive improve and we can visit well-trained physiotherapists if we are having trouble moving. Any inability to move is hard, but perhaps we are most hampered when we are not mobile. Imagine what this is like!! People may be immobile as the result of accidents or from problems they are born with, but every effort is made to give them supports to help them be more mobile. Many use wheelchairs, some use lifts to help them get in and out of bed or up stairs and, at the very basic level, they use sticks or crutches to help improve their mobility.

Physiotherapists who manage and treat movement disorders study the science of movement. This involves looking at how the muscles, tendons ligaments and bones in our body interact to produce movement. Chicken wings from the supermarket are useful in showing bone, muscle, ligaments and tendons in action. Sometimes a student in your class may have a parent or friend who works as a 'physio' or in a similar area—invite such a person to talk to your class about what they do and the science they studied to become involved in this career.

When students come to this topic they will often be familiar with movement in the vertebrates, but may have little awareness of movement in plants or in the invertebrates. They will generally know that birds fly, fish swim and that mammals, amphibians and some reptiles use their legs or, in the case of snakes, move without legs. Many will have little understanding of plant movements or the difference between the terms 'movement' and 'mobility'. Focus on extending your children's understanding of movement in both plants and animals, how it helps them survive and why animals need to be mobile to collect their food and plants don't because they make their food. Keeping snails, other invertebrates and plants in your classroom is always a good idea.

Plant movements can be slow and not easily seen as they turn towards the Sun or grow towards a light source or water. Although most plant movements are very slow, some are rapid, for example, the response of a

Venus flytrap when an insect lands on it or the closing of the leaves of some plants if they are touched.

When we look at the way animals move we see a great deal of variation—rapid movements, very slow movements, movements that involve specialised appendages such as legs, arms, wings and fins and movements that require no special limbs. Animals can move in water, on land and in the air. They can produce movements with structures that are similar in function but quite different in structure. The wings of birds produce a movement similar to the wings of an insect but the structure of an insect wing is very different to that of a bird—no bones or feathers for a start.

Movement in both plants and animals helps them survive. Plants make movements to get the things they need to make food—they turn to face the light and their roots bend towards water in the soil. Carnivorous plants such as a Venus Fly Trap live in soils where there are inadequate nutrients and catch insects to provide these.

Scientists have studied the way things move by watching them and, in the case of animals, dissecting them to find out more about the structures involved. It is often difficult to watch plant and animal movement in natural situations because plant movements are often slow and animal movements are fast. There are some wonderful film clips of plant and animal movements. Film, photographs and drawings are used to share information about movement as well as to collect information. Every year there are many programs shown on TV that help us learn more about the way living things move. Moving pictures help us look at the process of movement as well as the structures involved—in still pictures we can see only the structures involved. We have all seen plants that move towards the light in certain situations and experiments about these movements are quite successful, for example, growing seedlings in pots covered by milk cartons with either a top or side removed. If you include such an experiment in this unit, it can bring opportunities to think about a 'fair test', to make predictions and to observe what actually happens.

YEAR 4

LIVING THINGS REPRODUCE

Investigating why and how living things reproduce

Suggested Time: 9 - 12 hours

Understanding Goals

1. Students begin to understand the problems that can occur in human populations because a reproductive balance is not maintained.
   a. Why has the human population grown so big? What are the problems associated with such a large population?
   b. How could we control this population? Is it ethical to control the human population?

2. Students begin to understand that living things reproduce.
   a. How do living things reproduce? Why do living things reproduce?
   b. What happens if living things produce too many offspring? What happens if living things produce too few offspring?
   c. How do living things change as they go from babies to adults?

3A. Students begin to understand that scientists can collect information about the reproductive habits of organisms by collecting samples and making observations.
   a. What can we learn about reproduction in living things by collecting samples from the environment?
   b. What tools help us make and record our observations?

3B. Students begin to understand that scientists use different formats to share the information they collect with different audiences.
   a. How can a picture book be used to share what you have learned in this unit?

Background Information

One of the characteristics of living things is that they can reproduce. In natural populations deaths usually stop populations getting too large, but in human populations we often save people from dying through the use of medicine or by supplying people with food and shelter after natural disasters such as fires, earthquakes, droughts or floods. As a result, the human population has grown exponentially. This topic gives you the opportunity to discuss ethical issues related to this growth. Should there be restrictions on the number of children people can have? Should we be providing food and medical aid after natural disasters? These are quite sophisticated issues for students of this age, but they will often have sufficient background to begin develop opinions from what they have seen on TV, heard discussed at home or seen in magazines or newspapers. You could introduce such ideas by considering pets, particularly cats and dogs and the ways in which we control their population sizes and what happens if these controls are taken away.

When we think of the science connected with reproduction, your students will have a wide range of understanding. Some may have a clear picture about human reproduction and others, a sketchy picture. Many may have only absorbed information about various egg laying animals and animals that have living young—many of the animals they understand about will be vertebrates. They will all have some knowledge that plants grow from seeds and they may have experimented with growing plants vegetatively—from potato eyes, for example. This unit is not intended to be a sex education unit, but to broaden students' ideas on the way in which both plants and animals reproduce and the reason they reproduce.

Organisms reproduce to provide continuity within a species. If domestic dogs and cats did not reproduce these animals would soon die out. Not all cats and dogs reproduce, nor do all humans, but some do and they are the ones responsible for the continuation of the species. Many animals give birth to live young—all mammals, except for the echidna and the platypus, some reptiles, some fish (sharks), a few amphibians and some invertebrates (aphids). Other animals lay eggs, which may be hard shelled (birds' eggs) or soft (frogs' eggs). The way organisms reproduce has evolved to provide the best chance for the survival of the 'baby' organisms.

Animals that are born alive have a good start because their early development takes place in the safety of their mothers' bodies. Those that develop from eggs have a greater risk of not surviving. Eggs may dry out if they have no shell or they may be eaten by predators. Some animals that have live young look after their babies well—this helps them survive. Egg-laying animals may also look after their young and these animals, such as birds, usually lay few eggs. Other egg laying animals such as frogs and insects don't look after their eggs or the young. These animals lay many eggs so at least some survive. Animals that produce only a few offspring usually look after these offspring well— they have a good chance of survival.

'Baby' plants can develop from seeds or from a part of the plant, such as the 'eye' of a potato. Plants don't care for their 'babies' and most don't survive to grow into adult plants. Therefore, plants often produce lots of seeds. If your children collect seedpods they will find vast differences in the number and size of seeds produced. Most students will have experienced growing plants from seed, but this is a good time to introduce other ways of growing plants—parents may be able to help here or you might take your class to a nursery.

Young plants and animals grow into adults and the reproductive cycle begins again. As they grow the appearance of the organism changes—baby mammals grow hair and birds grow feathers. Some undergo very distinct changes—tadpoles become frogs and caterpillars emerge from their cocoon as butterflies. Young animals of different species can look quite similar before they develop their adult features—think of the story of 'The Ugly Duckling'.

This unit provides opportunities for making collections. Frogs' eggs and tadpoles are generally easy to find at certain times of the year and often students have kittens or puppies available for observation. Vegetables can be used to explore vegetative reproduction and there are many beautiful picture books written to teach children about plants and animals and the way they reproduce. Perhaps your children could create their own picture book about what they have learned.

SCIENCE as KNOWLEDGE
MATTER

Understanding of these ideas will grow through the primary years

- There are many different materials available.
- Scientists classify materials using their properties and their sources.
- The properties of materials can be changed.
- The properties of materials determine their uses.

YEAR 1
MATERIALS WE USE
Investigating the range of materials in our lives

Suggested Time: 9 - 12 hours

Understanding Goals

1. Students begin to understand how we use materials in our lives.
   a. What sorts of materials do we use? Can you give examples?
   b. Are the objects we use made from more than one type of material? Can you give examples?
   c. How have the materials we use today changed from those used by early humans?
   d. Where do the materials we use come from? Why should we try to re-use materials?

2. Students begin to understand there are many different types of materials.
   a. What is a material? How can materials be sorted?
   b. What properties can materials have? Which properties can we see? Which properties can't we see?
   c. Does the form of a material affect its properties?

3A. Students will begin to understand that scientists can collect information about materials by making observations and doing tests.
   a. What sorts of information can scientists collect about materials by using sight, touch and smell?
   b. What information can a scientist collect about a material by testing it?

3B. Students will begin to understand how words can be used to describe and record information about materials.
   a. What words do we use to describe the properties of materials? What do these words mean?
   b. How can a table be used to record the information we find out about an object or a material?

Background Information

When students start this unit, they will often think of materials as fabrics used to make clothes. One of the main purposes of the unit is to extend their understanding to include the bigger idea of materials being the substances from which things are made. Students in this age group will have come across many materials—materials used for making clothes, building structures such as houses, large buildings and bridges, for making vehicles, for making the things in buildings such as furniture, carpets and electrical goods—but they may not have thought about why these things are used or where they have come from. We usually sort materials by their uses or their properties.

There are lots of different words to describe the physical properties of materials and we use our sense of touch, sight and smell to find out what materials are like. Some materials are flexible (bendy) like some plastics and others are rigid like wood. Some are strong like the metal used to make boats, but others are weak and easily broken like the china used in plates and cups. Some materials are transparent like the glass in windows, but many others, like wood and metal, don't let light through. These materials are said to be opaque. The same material can change depending on how it has been made. The aluminium metal used in dinghies is strong and rigid, but the aluminium foil in the kitchen cupboard is flexible and not very strong. Materials can feel different depending on how they have been manufactured. Some woollen fabrics feel soft and smooth, but others feel very hard and rough. Materials can have different smells and some have no smell at all. Materials can be different colours. Some of this colour can be natural or it may be colour we add—this happens when we dye the cloth from which we make clothes.

We choose the material we use for a particular purpose because of its properties. When we build a house we choose strong materials—wood, metal and brick. When we make windows we usually choose glass. It won't let in the wind or rain, but it will let in the light. When we make clothes we choose materials that are flexible, that feel nice on our skin, which can be dyed to different colours and can be washed easily when we get them dirty.

Humans have always used materials but the materials we use now are more processed and are not just natural materials. Very early humans wore clothes made from animal skins and grasses, used rocks and bones as their tools and made houses and bridges from trees cut from their environment. Scientists have played a big role in the development of the materials we use today. The materials we use are often not renewable, and we must take care not to waste them. You can introduce questions about why re-using materials is so important.

This unit brings many opportunities for activities. Perhaps your children could dye some cloth or smell, touch and feel materials and find the words that describe them. You can do some testing—perhaps to find the absorbency of different materials such as those used to make kitchen sponges or materials that you might use to make clothes you want to dry quickly. They could test the strength of different threads or you may want to show how much stronger a rolled sheet of newspaper is when compared to one that is not.

Your children can make things using different materials and write, perhaps with your help, about each of the materials. There are many activities to engage your students in this topic, but remember you need to keep asking the questions.

'I believe that much of present education fails because it neglects this fundamental principle of the school as a form of community life'
John Dewey

YEAR 2

MATERIALS FOR KEEPING WARM AND DRY

Investigating materials that are heat insulators and/or waterproof

Suggested Time: 9 - 12 hours

Understanding Goals

1. Students begin to understand that waterproof and insulating materials are used to make a wide range of products.
   a. What do we use waterproof materials for?
   b. What do we use heat insulating materials for?
   c. When do we need to use materials that are both waterproof and heat insulators?

2. Students will begin to understand that materials have a variety of properties.
   a. What materials are waterproof? What does it mean to be waterproof?
   b. What materials are good heat insulators? What does it mean to be a heat insulator?
   c. What other properties can waterproof/insulating materials have?

3A. Students begin to understand that scientists can collect information about waterproof/insulating materials by testing them and making measurements.
   a. Which materials do you think will be waterproof? How could we test this? How could we measure how waterproof a material is?
   b. Which materials do you think will be heat insulators? How could we test this? What could we measure?

3B. Students begin to understand that information gathered from testing materials can be shown in different ways.
   a. How could we show someone else how we set up our tests?
   b. How could we show someone else the results of our experiment?

Background Information

We use many materials in our lives. Some of these materials are waterproof some are good heat insulators and others are both. Waterproof materials are used in a variety of things—we often use them for clothing and building. The most common reason we use waterproof materials is to keep out rain. Most people have at least one or two pieces of waterproof clothing, but we also use waterproof clothing for protection in circumstances other than when it is raining. Fishermen wear waterproof clothing and boots to protect them from the waves that break over their boats. We might wear waterproof gloves to do the washing up to protect our hands from the detergent and scientists wear waterproof gloves to protect their hands from harmful chemicals. We don't only use waterproof materials to make clothes. We use them in our houses. It wouldn't be any good to build a house from stone/wood/aluminium/glass unless these products were waterproof.

Heat insulating materials help keep us warm—we all have clothes that are warm, especially for winter. Wool is a very good material for keeping us warm, just like it keeps sheep warm. Wool is a natural material, but there are lots of man-made materials that keep us warm—polar fleece is a good example. People often wear warm clothing because of their jobs. People who work in Antarctica need warm clothes, so do postmen who ride on motorbikes even in winter and policemen/women who patrol our streets. Insulating materials are also used in buildings. Many of these are not waterproof, like the insulation we put in walls and roofs of houses or straw bales some people use to build houses. If people use straw bales they must add a coating to make them waterproof. Newspaper is a good insulator and it is not unknown for poor homeless people to put layers of newspaper under their clothing to help them keep warm. It is easy to test the insulating properties of newspaper by monitoring how quickly the temperature drops in two tin cans, one wrapped with newspaper or one without or perhaps you could do a similar experiment with ice-cubes—to see how well newspaper can prevent them from melting.

Clothing is often heat insulating and waterproof and houses are built from materials that are both waterproof and good heat insulators such as wood and stone. Firefighters wear clothing that is waterproof and heat-insulating when fighting fires and Antarctic workers also wear clothing that is warm and waterproof. Invite a firefighter or Antarctic worker who may wear waterproof and insulating clothing to visit your school.

Materials that are waterproof are ones that don't let water in but often their other properties are different. We can get strong/weak waterproof materials and flexible/rigid waterproof materials. Often a material can come in more than one form. Aluminium for example can be rigid and strong when it is in the form used to make boats, but it is flexible and not very strong when it is rolled out to form aluminium foil. Some materials are better than others at keeping water out—glass, plastic and metal are very good. Objects made of wood or clay may seem waterproof at first but eventually let water through. Often we paint these to make them last longer. Some materials that you don't think are waterproof such as paper can be made waterproof by being specially treated, as is the case with paper cups. An origami cup made of printing paper will hold water quite well for a short time. Your children may like to test cups made of different papers.

We choose the waterproof material best suited for its purpose. Some forms are best for constructing and others for clothing. We don't build houses out of raincoat material and we don't make raincoats out of glass!! Building materials usually need to be strong, they often need to be rigid and sometimes they need to be transparent. Materials used for coats and hats need to be soft and flexible so when we wear these clothes we can be comfortable and move. The materials we use for gumboots and shoes need to be less flexible than those in coats.

Heat insulating materials don't allow heat to pass through easily. They can be used to keep things cold or hot by stopping the heat from outside passing through to the inside. An 'Eski' stops the heat from outside travelling in and warming the food and drinks. A hot drink flask keeps the heat from escaping. Wool, feathers, straw and paper are good because of the air they trap—air is a good insulator. A feather quilt is good for winter.

This unit lends itself to testing materials, making predictions, using a thermometer and recording information using graphs and tables. Students could also use photographs or labelled drawings to show someone else how they set up their test. These need to be clear so that other people could set up the test in exactly the same way.

YEAR 3

MATERIALS CAN CHANGE

Investigating the effects of temperature on materials

Suggested Time: 9 - 12 hours

Understanding Goals

1. Students begin to understand that we must consider the effect of temperature on materials before we choose to use them.

   a. How does temperature affect some of the common materials we use?
   b. What common foods begin to melt as temperature increases? How can we reduce this effect?
   c. What precautions would you take if a bushfire was coming towards your house?

2. Students begin to understand that materials can change with temperature.

   a. What are some of the physical changes we see in our everyday lives?
   b. What are some of the chemical changes we see in our everyday lives?
   c. How can the form of a substance affect the way it behaves as temperature increases?

3A Students begin to understand that information about materials can be collected from primary and secondary sources.

   a. Students begin to plan some experiments to test how some common substances are affected by temperature and how the form the substances are in might cause differences in their behaviour. How will you collect and record this data?
   b. What can we learn about materials by looking at second-hand data about them?

3B Students begin to understand that what they have learned about materials can be shared in a variety of ways.

   a. How might we share what we have learned using graphs and tables?
   b. How could we report what we have learned as a story for a newspaper?

Background Information

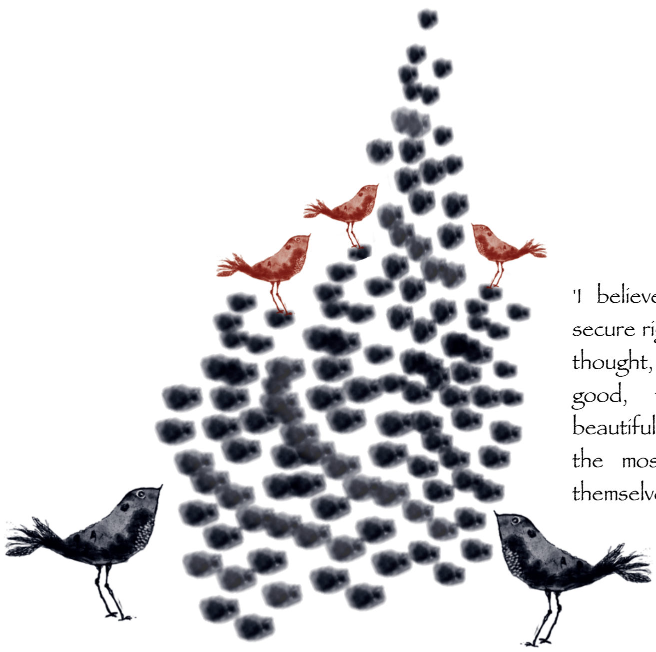
Temperature can affect many of the materials or substances in our lives and how we use them. One of the biggest effects we see is that many substances will soften or even melt as the temperature increases. Things we eat like chocolate and butter melt at quite low temperatures and we need to keep them in the fridge when it gets too hot. The tar on the roads can often melt in high temperatures and many plastics will soften on hot days or melt at quite low temperatures in the microwave or in the oven. As these substances change, their characteristics change—the tar on the road becomes sticky, the butter, chocolate and plastic won't hold their shape. We must think about the effect of heat on different materials before we choose to use to make different objects. It is no use making ovenware out of plastics that melt at low temperatures and, in Tasmania, it would be no use building an igloo to live in!! Many liquids we use will evaporate as the temperature increases and in hot weather we need to continually water the garden and fill the bird baths as the water evaporates. We also make use of the fact that water evaporates to dry our clothes and to dry ourselves if we forget to take a towel when we go for a swim. The changes I have spoken of are called 'physical changes'—they are ones that can be reversed.

Other substances we use may harden with temperature and others will begin to burn. When clay is baked in a kiln it becomes hard and strong. This is how we make bricks to build houses and how we make crockery and ornaments. 'Fimo' and other polymer (plastic) clays can be easily moulded into different shapes before they are heated but, like natural clays, they change their physical and chemical properties so we can no longer change them back to what they were. When we put a 'sloppy' cake mixture into the oven it becomes firm and solid and after we have boiled an egg its contents become solid and we can no longer crack the egg and let the contents flow. If we heat substances such as paper, wood and textiles to high temperatures they start to burn. Fortunately, these temperatures, known as the ignition points, are higher than we normally get or we would have materials catching fire all around us. In bushfires this is what happens when we see houses and vegetation bursting into flame. Sometimes, if hay is stored in stacks, it will spontaneously burst into flame as the temperature inside the stack increases due to the action of bacteria. Once the materials have burnt they are completely changed and are not recoverable. These types of changes are not reversible and we call them chemical changes.

There are many activities you can do so your children get a feel for the difference between chemical and physical changes. Melting chocolate and butter are always good things to do, especially when it is a warm, sunny day. You might try different brands of chocolate to see if there are differences in the time they take to melt or you might grate some chocolate and see if it melts more quickly than chocolate in squares. There are many resources online which will give you ideas for exploring melting and physical change.

When you are ready to do some practical activities that demonstrate chemical change, think about using polymer clay that hardens in normal household ovens or bring in some sparklers to burn. Again the Internet is a great resource for ideas and you understand what will excite your children.

Your children might be ready to start planning some simple experiments themselves and may be able to design their own data tables and graphs with some help. I have found second-hand data about melting points, boiling points and ignition points is readily available and it is a good way of introducing children to reading information from tables or graphs.



'I believe that if we can only secure right habits of action and thought, with reference to the good, the true, and the beautiful, the emotions will for the most part take care of themselves.' John Dewey

YEAR 4

MATERIALS USED IN WATER

Investigating the special properties needed by materials used for objects in water

Suggested Time: 9 - 12 hours

Understanding Goals

1. Students begin to understand how humans have overcome problems that occur when materials are used in water.
   a. Why have humans been so keen to make objects to be used in water?
   b. What problems result from using materials in water?
   c. How have these problems been overcome?

2. Students begin to understand about the special properties needed by materials used in water.
   a. What sorts of materials are good to use in a watery environment?
   b. What are the properties of these materials?
   c. How do we protect these materials?

3A. Students recognise the importance of experimenting to collect information about materials.
   a. What experiments can we do? What do we think will happen? What does happen?
   b. How will we record our results?
   c. Could we improve our experiments?

3B. Students understand that different methods of communicating can be used for different audiences.
   a. How can you share what you have learned about materials we use in water with your peers/your parents/the school, justify your choice and carry out the method you have chosen?

Background Information

From the very earliest of times humans have used objects in water. They have built boats, made nets, built fish traps and made jetties and bridges so they can fish in lakes and travel across water. At first the materials they used were taken from the natural environment—mostly wood and stone to make bridges, bark or wood for boats and natural fibres for making nets and traps. Many of these materials rotted quickly and needed to be replaced—we don't have many relics of such items. The boats they built were as simple as a hollowed log or some bark bound together with natural fibres.

As our knowledge of science has increased we have produced a much wider range of materials that we can use in the water and have found ways of preserving materials in their watery environment. We have found out about the role that shape plays in making things float and now we make huge boats that carry goods and people around the world. We use many objects in our lives that float on water and others that we want to sink. For example, floating objects we use are found in toilet cisterns, for fishing floats, buoys to tie boats to and 'floaties' when we are learning to swim. There are some objects that we want to sink, such as boat moorings, anchors, fishing sinkers and ornaments in the fish aquarium.

Some of the science in this unit is quite complex. We will focus on some of the more simple things. There are many materials that are good to use in water but these sometimes need to be treated in special ways before they are used. If they are not treated they often rust if they are metal or rot if wooden. Iron is used to make boats and other objects because it is cheap and readily available, however iron rusts in water so we have had to develop ways of overcoming this. To stop these objects from rusting they are protected from the water by being painted. This is often a continuous process on big ships. Other metals such as aluminium and stainless steel don't rust easily and no paint is needed, but these metals are more expensive than iron and usually only small vessels are made from these. Wood, like iron, is quite a good material for using in the water, particularly as it floats but it also deteriorates in water unless it is painted or oiled. Plastics are cheap and they don't rust or rot in water, but they can deteriorate if left in there for too long—you can find a lot of broken plastic on beaches.

Many people think that the objects that float on water need to be made from materials that float but this is not always the case. Certainly we use materials that float to make some objects we use in water. We use cork to make the floats on fishing nets and foam plastics to make kickboards. Boats float on water but these can be made of materials that don't float, often iron or aluminium. This is because it is the shape of the boat that determines whether or not it will float. A piece of aluminium foil shaped into a ball or a lump of plasticine dropped into water will sink but if either material is shaped into a 'boat' it will float. The science to explain all this is connected to density and, although most of your students won't understand these ideas, the effects are easy and important to see. Some objects we use in water we want to sink and we choose the materials in these objects because they sink in water. To make objects such as anchors we would choose metals, concrete and rocks.

One of the most important ideas to emerge from this unit is that we must choose the materials we use in a watery environment very carefully or we will end up with many problems.

The opportunities to investigate and test materials in this unit are endless and your students should be able to do most of their learning in this way. They can investigate different ways of stopping iron from rusting (many nails have coatings that stop them from rusting but steel wool contains iron and usually rusts quite quickly if you wet it and leave it in the air—you might want to see what happens if you put wet steel wool in a cliplock bag and compare it to some that is in direct contact with oxygen in the air. They can look at the effects of water on plastics and they can investigate ways of getting materials such as plasticine and iron to float—they can make plasticine and foil boats. The Internet is your best resource.

Since the information in this unit is very helpful for the general population to understand so that they can protect their belongings from water damage, it is a good unit for your students to share their learning with a wider audience.

SCIENCE as KNOWLEDGE
EARTH and SPACE

Understanding of these ideas will grow through the primary years

- Natural movements of the Earth determine regular changes.
- Humans have used natural movements of the Earth as a basis of measuring time.
- The Earth acts as a resource for materials.
- The natural conditions of the Earth support life on Earth.
- Earth is part of a bigger picture–the Solar System and the Universe.

YEAR 1

SEASONS AND THEIR EFFECTS

Looking at how the seasons affect the living and non-living world

Suggested Time: 9 - 12 hours

Understanding Goals

1. Students begin to understand how the seasons impact on their lives.
    a. How do we dress and behave in the different seasons? Why do we need to change the way we dress and behave?
    b. Why are the seasons important to our survival?
    c. Do all places in the world experience the same seasons?

2. Students begin to understand that the seasons affect the appearance and/or the behaviour of plants and animals.
    a. What sorts of differences do we see in plants and animals as the seasons change? Why do these changes happen?
    b. How do these differences help plants and animals survive?

3A. Students begin to understand that scientists can find out more about the effects of the seasons by experimenting and by collecting information from secondary sources.
    a. What can we find out from books or the Internet about how animals and plants change with the seasons?
    b. What can we find out about temperature, rainfall and daylight hours in different seasons by looking at second-hand data?
    c. What experiment could we do to find out about the effect of seasons on plants?

3B. Students begin to understand that scientists need to communicate in different ways to suit different audiences.
    a. What sort of audience might learn from a poster? What would make this poster a good means of communicating?
    b. When is it appropriate to use tables and graphs for recording and communicating information?

Background Information

The seasons have been observed by humans for as long as can be remembered and there are many references to the seasons in literature. They are important to humans because the different conditions, particularly temperature, rain and sunlight, produce different growing conditions—humans rely on plant and animal growth for food. If we live in temperate regions we often think of the seasons as spring, summer, winter and autumn, but if we live in other regions of the world, including Northern Australia, we experience a tropical climate—where we refer to the seasons as 'The Wet' and 'The Dry'. Some areas of Australia are almost always dry and hot. Our lives are often regulated by the seasons because we live differently in different seasons. In summer we can wear light clothes because of warmer temperatures, we can be outside in the light until late and we are less likely to have rain. In winter we dress more warmly, spend more time indoors and often have to put on our wet weather clothes. In 'The Wet' season it is still warm but rainy, we might want a raincoat or an umbrella. Even if we do not know what season it is we could soon guess by looking at what is going on around us and how the landscape looks.

The science behind the seasons is quite complex—the changing seasons are the result of the Earth's tilt, its revolution around the Sun and numerous other factors. The science is difficult for many children of this age, but they can consider the effects of the seasons on the plants and animals in the world and begin to understand the importance of Sun and water in our lives.

Hibernation, emigration and changing coat colour are all things that animals do with the seasons as we know them. Each feature helps the animal survive. Some animals hibernate in winter. Before winter starts they eat and grow fat and some store food in a hole or nest. Whilst winter is on they spend much of their time sleeping, relying on the energy they have stored on their bodies or that they have stored away in their homes. Other animals become very slow in winter because of the low temperatures. We rarely see snakes and lizards in winter because their bodies are not warm enough to allow them to move. Some animals migrate according to the season—many birds are migratory, they move around with the seasons to where they can get food and so increase their chances of survival. Other animals change the colour of their coat with the seasons. The Arctic hare is white in winter so that it is camouflaged against the snow and brown in summer when the snow has gone. Most animals living in the natural environment will have babies in when the weather gives their babies the best chance of surviving.

Plants also respond to the seasons. In temperate zones many plants flower and grow rapidly when there is warmth and spring rain. By autumn many fruits have formed and in natural circumstances the seeds in these fruits are dispersed so that they might germinate in the next spring when the weather conditions are right. In autumn some plants lose their leaves and become dormant (almost asleep) in winter. The 'food' in their leaves is reabsorbed by the plant to help it survive the winter. These plants usually come from places where there is not enough winter sunlight for them to make their food. In tropical areas plant growth is usually lush, thick and difficult to walk through. These forests are home to many animals and sources of many medicines. In dry areas of Australia the vegetation is sparse, but reappears and grows rapidly in response to the rain. Animals, particularly birds, flood into these areas when this happens and leave again or die when no rain comes. Lake Eyre, *Kati Thanda*, is a good example of a dry area in Australia that has an occasional wet season.

This unit is very suitable for students to start to extend their understanding of different places people live and the variety of plants and animals and how they are affected by the seasons. There are beautiful films and stories that can be used as resources and many children will want to share their own experiences of being in places with different climates. Together you can look at some second-hand data about temperatures, rainfall and the length of the days at different times of the year so students begin to get a feel of what it might be like to live in a different place. Your children can collect information from their own experiments. They can experiment with seeds to see if they would germinate in the cold days of winter (in the fridge) or whether they need warmth to germinate. How would they do this experiment? What information would they collect from it? What do they predict will happen?

YEAR 2

NIGHT AND DAY

Comparing night and day, what causes them and the impact they have on life on Earth

Suggested Time: 9 - 12 hours

Understanding Goals

1. Students grow to understand how night and day affects humans.
   a. What different explanations have humans had over time to explain night and day?
   b. What sort of things do we do at night? What do we do during the day?
   c. How do we create an environment suitable for our needs during the night and day?
2. Students begin to understand the causes and effects of night and day.
   a. How are night and day different? Why are nights and days different?
   b. Are days and nights always the same length? Why?
   c. What effects do night and day have on plants and animals?

3A. Students begin to understand how scientists collect information about night and day by making observations and measuring.

   a. What information can scientists collect about night and day using a thermometer?
   b. What can we observe about the Sun's position as a day passes?

3B. Students explore how pictures and graphs can be used to communicate information.

   a. How can changes in temperature be recorded?
   b. How can our observations about the Sun during the day be recorded?

Background Information

Humans have always been interested in the way the world works and one of the phenomena we have always tried to understand is why we have night and day. Until we sorted out the Solar System with the Sun at it centre and the planets rotating around it there were many different stories from different cultures about night and day. This could be a good starting point for the unit as your students could listen to a mythical story about why we have night and day or they could write and/or illustrate one they create themselves. In both cases you will be able to find out what your students know about the cause of night and day. Many will believe that the Sun moves around the Earth as we say the Sun 'gets up', we see it changing position and then it 'goes down'. Most will not really understand what happens when the Sun 'goes down'.

The Sun is very important as it gives us light and heat during the day. For this reason it is during the daylight hours that humans are most active, although we are able to produce light and heat from other sources so that we can still be active in the darkness. For most of us we spend at least some of the hours of darkness sleeping, but some people work through the dark hours and sleep in the daylight.

We often talk of night and day, but our use of language is often not precise as a day is actually a 24-hour time period and we should talk of darkness and daylight. In the dark hours your children will know we can see the stars and the Moon and during the light hours we see the Sun if it is not covered in clouds. They may know that sometimes we see the Moon during the day but it is not very clear, and they are probably unaware that the stars are still there during the day, but are not visible because of the strong light from the Sun—just like when you put on a torch in the strong sunlight, the light it produces does not seem significant. This unit will look at extending their understanding of night and day by providing them with opportunities to see how the Earth rotates in relation to the Sun and they will also begin to understand why one side of Earth has daylight and the other side has darkness. The Sun is important to life on Earth as a source of heat and a source of light. Without the Sun the Earth would be a very cold, dark place and nothing would survive, as plants wouldn't grow and animals would have no food.

Animals that are active at night (nocturnal animals) often have special adaptations to cope with darkness. They often have well-developed ears so that they make more use of their hearing than other animals and they may also have eyes that are better at seeing at low light levels, unlike our human eyes. Some animals, such as bats, have developed a special 'radar' system for detecting objects at night. This is very efficient and bats fly around quite easily even in complete darkness. Owls are a good example of an animal that sees well at night.

Information about the temperature can be collected using a thermometer and can be recorded in a table or a chart so that it is clear to see. A thermometer is an accurate measuring device that has been invented by scientists and is a much more accurate way of recording information about how hot or cold it is than using words. Words such as warm, freezing, boiling, chilly, icy, hot and cold are common terms used to describe the temperature but they are not consistent—they don't mean the same to everyone and are therefore not very useful to scientists. Your children can collect information about temperature by looking at data collected from other sources and by measuring the temperature at different times of the day. They can put their hands in water at different temperatures to see what it would be like to be a penguin inhabiting cold regions where the water has not been warmed by the Sun or a green-backed turtle that prefers the warmer water of tropical zones.

'I believe that when science and art thus join hands the most commanding motive for human action will be reached; the most genuine springs of human conduct aroused and the best service that human nature is capable of guaranteed.' John Dewey

YEAR 3
WATER AND SOIL
Investigating the conditions on Earth necessary to support plant life

Suggested Time: 9 - 12 hours

Understanding Goals

1. Students begin to understand that humans rely on plant growth to survive.

   a. Why is it important that humans grow plants?
   b. What do scientists do to help make sure plants grow?
   c. What happens if conditions are not suitable for plant growth? How does this affect our lives?

2. Students begin to understand that water and the soil influence where plants grow.

   a. What is soil? How is soil formed? How do soils differ? Do plants grow better in some soils than in others?
   b. Is water necessary for plants to grow? Are some plants better adapted to grow in dry conditions?
   c. How do different combinations of soil and water affect plant growth?

3A. Students begin to understand that scientists can investigate soil and water and their effects on the growth of plants by collecting information from experiments.

   a. What experiments will help us to find out about soil and water and their effects on plant growth? What do we expect to happen in these experiments? What does happen?
   b. How will we record our results?

3B. Students begin to understand how they can share their understanding of water and soil and how they affect plant growth with others.

   a. How might we share our knowledge of growing plants with our parents and friends who have a garden?

Background Information

Humans are very dependent on the conditions on the Earth's surface for survival. Generally we have settled in places where there is water, where the soil is fertile and temperatures are suitable for plant growth. Unfortunately these conditions sometimes change as a result of natural events, and places that once supported the growth of crops will no longer do so and the humans who have settled in these regions suffer. One of the critical factors seems to be water and another is the soil. Many places in the world experience drought when the rain they expect just doesn't come. In many places they are lucky because food can be sourced from areas not suffering from drought. For the farmers on drought- stricken properties it is very hard as they watch their crops fail and their animals die because they have no food. Scientists help by developing plants that need less water to survive. We can also use these plants in our own gardens to help reduce water use. Scientists have helped make land where the soil is not good for plant growth much better by creating fertilisers that can be added to the soil to help plants grow there. Scientists have had little luck in making it rain in areas where there is little rain.

Your children will already have some knowledge and understanding about the importance of water to plants for growth, but they may not have had much experience with soil. Soils are formed from the breakdown of rocks and the addition of animal and plant materials over very long periods of time. Soils are different from each other in many ways—their composition, their 'stickiness' and their colour. They are usually classified as sandy soils, clay soils or silt soils but most are mixtures of these inorganic materials (not sourced from living things) and organic material called 'humus' (rotted plant and animal material). The amount of humus in soils varies a lot. Poor soils usually don't contain much humus whereas good soils do. Soils that don't contain much humus don't hold water very well adding to the problem for plants growing in poor soils in dry areas. Although plants will often grow in poor soils, their growth is often much less than in rich soils, but no matter how good the soil is, plants won't grow without water.

Just like soils are different from each other, plants are different especially in the amount of water they need to survive. Some plants are much better suited to growing in dry conditions than others—think of many of our

Australian native plants and how they survive in summer compared with some of the imported plants we try to grow in our gardens. Scientists are always looking at creating drought-resistant plants, especially crop plants. They do this by selectively breeding plants for their drought resistance or by genetically modifying plants. The water that plants need comes from rivers and lakes that are filled by rain as a result of the water cycle. This unit does not consider the water cycle as such, but students should understand that it is a natural cycle on Earth over which we have little control. Some places are nearly always dry and these places are often not settled, but others are marginal areas—some years they have good rains and in others they don't. These regions are the most at risk and if rains don't happen then plants soon stop growing. If plants stop growing then animals can't get food. As a result the land becomes barren no matter how good the soil is.

This unit is a very good one for your class to get actively involved in—you may take them on field trips to visit different areas where drought might be happening and see the effects of this on the land or to a nursery where they can look at plants which have been developed for their drought tolerance. It also gives them a chance for experimenting and making observations about soils and how plants grow in different soils with or without water. If you have access to a school garden it is a good way for your students to connect their work in the garden with what they are doing in science.

The unit is very important given the possible changing nature of our climate with global warming and it provides a good opportunity for students to share their learning with others, especially their understanding of drought-tolerant plants and the importance of these in our gardens.

YEAR 4

TIME AND THE SOLAR SYSTEM

Investigating the place of Earth in the Solar System and comparing Earth with other planets

Suggested Time: 9 - 12 hours

Understanding Goals

1. Students begin to understand that humans have always wanted to find out about the Earth and its position in the Universe.
   a. What explanations have humans given about the Earth and its position in space over time?
   b. What tools have been invented to find out more about Earth's place in the Universe? Who are the people who have made these tools?
   c. Should we spend so much money on space exploration?

2. Students begin to understand the place of Earth in the Solar System.
   a. What is the Solar System? How do we use the movement of Earth in the Solar System to measure time?
   b. How are the planets in the Solar System similar to and different from each other? What effects do these differences result in?
   c. Why is the Sun so important to life on Earth? Why do we think there may be life on Earth but not on other planets?

3A. Students begin to understand that information can be collected from primary and secondary sources.
   a. What are primary and secondary sources from which we collect information?
   b. How do we know whether an experiment designed to collect information from a primary source is a fair test?

3B. Students begin to understand that the ways in which information is organised can make it more usable.
   a. How does information in visual organisers such as tables and diagrams help us look for similarities, differences and trends?

Background Information

Most students will come to this unit knowing something about the planets and some may know quite a lot because there are many programs and children's books about them. They will generally understand the effects that darkness and daylight have on Earth, they will be able to describe the effects of the different seasons and hopefully they are beginning to understand that daylight and darkness are the result of the Earth rotating and not the Sun moving. Your role in this unit is to reinforce these ideas and start to develop a bigger picture view of our Solar System, why life as we know it has only developed on Earth and how we have used the natural movements of the Earth to identify time periods.

From early times humans have been interested in finding out about our Solar System and the Universe. At first our knowledge was limited, as we didn't have the tools to find out much. There were myths and stories developed about the Sun, the planets in our Solar System and the stars and for many years it was believed that Earth was at the centre of the Solar System. With the development of telescopes and spacecraft we now know more about our Solar System and the stars beyond. Many people argue that we should not spend money and time investigating space when we have enough problems on Earth, but others believe it is important to understand our Universe and the beneficial 'spinoffs' that can come from the research—websites describe these benefits. In this unit you give your class opportunities to understand the history of space exploration, and they can air their views about the money spent exploring space. Your children will often know a lot of facts about the planets and so your main purpose will be to extend their thinking and ponder the future. This unit brings many possibilities for creative writing.

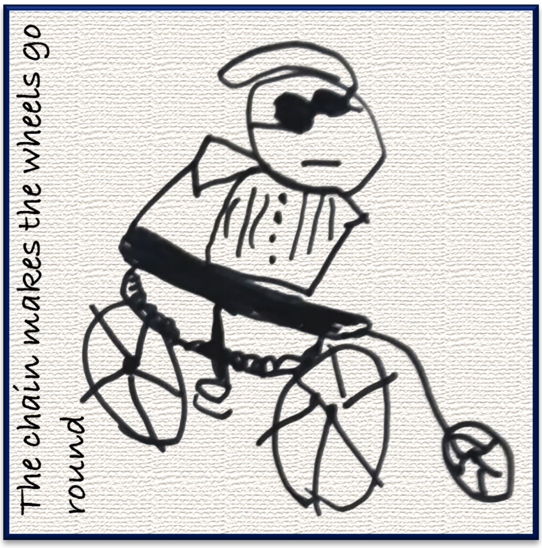
Our Solar System consists of the Sun and the planets. The Sun is a star that produces heat and light. Our Solar System is a small part of the Universe in which there are many other stars, some of which will be the centre of other planetary systems. The size of our Solar System and the Universe is beyond comprehension for most of us. If we look at posters of the Solar System we will see an attempt has been made to show the relative sizes of the planets and their distance from the Sun. This is not the true picture. If we really want to represent the relative distances of the planets and Earth was represented as the size of a pea then Jupiter would be about 300m away from Earth and Pluto 2.5km from Earth!!

The planets have many similar characteristics. None produce their own light and heat—they are not stars like the Sun and they rely on the Sun to provide heat and light. They all rotate on an axis and they all revolve around the Sun. Of course, the planets are different sizes and they are different distances from the Sun—because of this their temperatures are different. They rotate at different speeds and so a 'day' varies from planet to planet and they take different times to revolve around the Sun resulting in different 'year' lengths on the different planets.

Life as we know it does not seem to exist on the planets, as they don't provide the conditions for plants to survive. In this unit we will look particularly at how the temperatures alone would prevent life as we know it on most planets. To sustain life on Earth we need plants but most of the planets are too cold and/or too hot for the plants we know to even germinate. Only Mars has temperatures like those on Earth. The lack of oxygen, water and, on some planets, long periods of darkness also make them unsuitable to support life as we know it.

This unit gives your class a chance to make models and find information from a variety of sources. There are opportunities for students to collect information from experiments and begin thinking about whether their experiments are 'fair tests'—make sure you are clear about this before you start. A simple experiment is to have containers of the same size and containing the same volume of water placed in the sunlight and others in the shade. You can extend this by using containers of different sizes. Your class can make predictions, record their results, discuss the purpose of the experiment, consider if it was a fair test and explain how it relates to the planets. You can ask them to think about whether their information comes from primary or secondary sources and ask them to question the reliability of what they see and hear.

SCIENCE as KNOWLEDGE
ENERGY and FORCE



Understanding of these ideas will grow through the primary years

- There are many different types of energy.
- Energy can be transformed from one type to another.
- Many sources of useful energy are non-renewable.
- Humans must use energy responsibly.

YEAR 1
ENERGY AND LIGHT
Investigating the sources and role of the light in our lives

Suggested Time: 9 - 12 hours

Understanding Goals

1. Students begin to understand the importance of light in our lives.
    a. How have the ways we produce light changed with time?
    b. What would our lives be like if we didn't have electricity in our homes?

2. Students will begin to understand that to produce light we must have a source of energy.
    a. Why do we need energy?
    b. Why do we need light?
    c. What natural objects produce light energy?
    d. What energy sources can we use to produce light?

3A. Students begin to understand the importance of gathering information by observation and testing.
    a. Which senses can we use to make observations about objects when there is no light?
    b. How can we test the reflective properties of materials?

3B. Students begin to understand that information needs to be communicated accurately.
    a. What words can we use to describe objects when there is no light?
    b. How can we record information collected from our tests?

Background Information

Without light humans can't see and so we have always produced light so we can see at night. When we have no light we often use our other senses to help us know where we are or what something is—touch and smell are very helpful. The sun is a natural form of light for humans, but in darkness hours other light sources must be used. From very early times, humans have burnt fuels such as wood and oils from plant and animal sources to produce light and in more modern times we have burnt gas. If we go camping we often use the burning wood of a campfire, gas and candles to give us light. The energy stored in these materials is used to produce light energy when they are burned. In our houses we usually use electricity as our source of light, but we may have torches and candles to use if the electricity is not working.

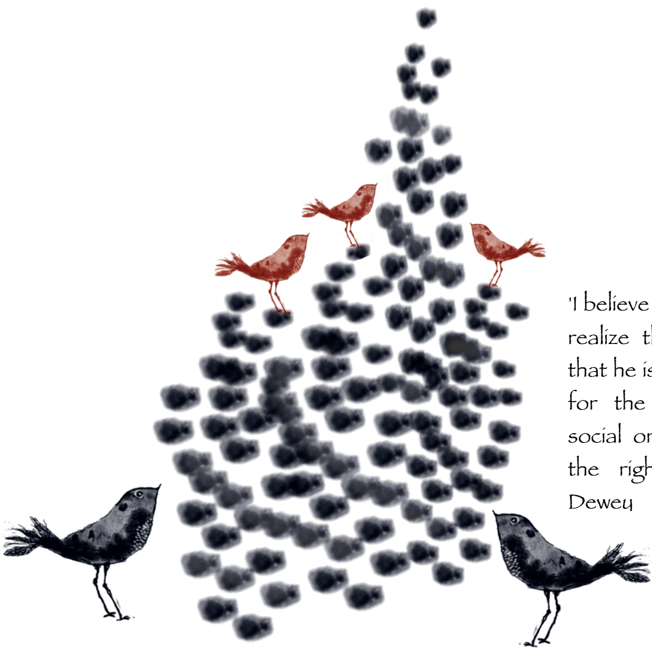
Light is a form of energy. Energy is quite hard to understand but we can think of energy as something that allows things to work. When we are 'doing work' in the classroom, running around outside or carrying a heavy object we are using energy from the food we eat. If the appliances in our house such as the oven, a radiator, a television or computer are 'working' then they are using energy. To produce light we need a source of energy, and if an object is 'working' to produce light by burning then it is using energy. When we turn on a light in the house the source of energy is electricity and if a torch is working it is using electrical energy from its battery. The Sun produces light energy that can travel through space to the Earth. Light energy can be produced by other natural sources. For example, by lightning, by stars other than the Sun and by some animals such as glow worms.

For simplicity the term 'using energy' is employed. At a later stage the more scientifically correct term 'transforming energy' will be introduced. This is because energy is not 'used up' in a device but changed from one form to another (or others) but this is an unnecessarily complex idea for students of this age.

We need light to see because most objects don't produce light themselves. We see them because light is reflected from them and if there is no light source then there is no light to reflect from the object. The reflected light goes into our eyes. If we go into a dark room we don't see anything even if we have our eyes open. As soon as we turn on a light, shine a torch or light a candle we will see the objects around us. If light levels are very low, we may see the outlines of the objects but it is often hard to see colours well. Some materials are specially designed to be very good at reflecting light, such as the reflectors on the back of shoes and sports jackets, the reflectors on the backs of cars and bikes and the reflectors on guide posts. Reflectors don't produce their own light.

This topic is a good one to work with your students on extending their vocabulary of descriptive words that can be used to describe 'feel' and 'smell'— as when we have no light we must recognise objects using senses other than sight. It is also a good chance to discuss the fact the words are not as precise as measurements because they are often used differently by different people.

It is also good opportunity to introduce/reinforce the idea of a test and to discuss ways in which this could be done and how the information could be recorded. A simple test would be to test different materials to see how well they reflect light from a torch.



'I believe that every teacher should realize the dignity of his calling; that he is a social servant set apart for the maintenance of proper social order and the securing of the right social growth.' John Dewey

YEAR 2

SOUND AND HEARING

Exploring different sounds and how we hear them

Suggested Time: 9 - 12 hours

Understanding Goals

1. Students begin to understand the importance of sound in our lives.
   a. How do we use sounds? What would life be like without sound?
   b. How have scientists helped people who can't hear?
2. Students begin to understand how we make and hear sounds.
   a. What is a sound? How can we make sounds? In what ways can we change the sounds we make?
   b. Where does the energy to make sounds come from? What do sounds need to travel from place to place?
   c. How do we detect sounds? What sorts of sounds can humans and other animals detect? Why is it important that we detect sounds?

3A. Students begin to understand that we can gather information about the ways sounds are made, travel and are detected by making observations of and drawing conclusions from simple investigations.
   a. What observations have we made in the investigations we have done on sound and hearing?
   b. What conclusions can we make from these investigations?

3B. Students begin to understand that sound itself is an important way to communicate.
   a. How can we use a verbal presentation to share information about our investigation?
   b. How will we make the presentation interesting and clear for other students to listen to?

Background Information

Humans have always made sounds. When we talk we make sounds, when we move we make sounds, when we play a musical instrument we make sounds, and if we drop something on the ground it makes sounds. Other animals make sounds as they move around, grunt, purr or bark, but plants are very quiet. We hear sounds through our ears but some people have damage to their ears and hear very little or nothing at all. Just imagine a world where we heard nothing. Our hearing helps us survive by warning us if there is danger—we hear cars coming or people shouting at us if we are in danger. People who are deaf don't have these advantages. As scientists have learned more about how we hear, they have been able to develop hearing aids to help people who are deaf. Some of these aids are worn on the outside of the ear but others are implanted into the ear— the bionic ear. Very loud sounds can damage our ears and people who work with loud noises, such as factory workers, often wear ear protection. Our ears can get damaged if we listen to loud music, particularly through earphones.

To make sounds we need to create a vibration. If we pluck a string or hit a drum it is quite easy to see the vibration but is not easy to see our vocal chords when we speak, although we can feel the vibration if we put our hand on our throat. To produce these vibrations, we must use energy. When we make sounds we use energy from the food we have eaten, when cars make sounds they use energy from petrol and when a radio makes sounds it uses electrical energy to produce these. Sounds can be loud or soft, high or low. As we move away from the source of the sound the sound gets softer.

The pitch of a sound depends on the length of the object that is vibrating. This is easy to see in musical instruments. If a guitar string is shortened by putting a finger on the string then the pitch gets higher, if the length of the column of air in a musical instrument such a recorder is shortened by uncovering some holes then the pitch increases. Similarly, if you make a sound by blowing over the top of an empty bottle you can make the pitch get higher by filling the bottle with water and shortening the column of air that can vibrate. To make sounds louder we use more energy—we must pluck a string more vigorously or strike a drum harder.

Sounds can travel through air, liquids and solids but they can't travel where there is a vacuum such as on the Moon. This is why astronauts on the Moon talk to each other with radios—sound waves can't travel between them because there is no air. When sounds travel through water we hear them differently. We have all experienced hearing sounds if we have our head under water in a pool or in a bath—they don't sound the same as when they travel through the air but they still reach our ears. Many of us will have watched movies where people put their ears to the ground or the railway track and pick up sound vibrations from a long way away. These vibrations travel more quickly through the railway track than through the air and so we will hear the train sooner if we listen to it through the metal of the track.

We can't hear all sounds. Some sounds are out of our hearing range as they are too high or too low. Animals have a different hearing range to us and dog owners may have whistles that their dog can hear but we can't. As humans get older their hearing range often changes and they are less able to hear high- pitched sounds. They also have trouble hearing soft sounds, which is why we often talk loudly to them and they have their televisions very loud.

Musical instruments are a very useful way of studying some of the ideas about sounds. Students can experiment with how the pitch can be changed and how the loudness can be changed. They will be able to see the strings vibrating on a guitar and they can watch the skin of a drum vibrate, especially if a few grains of rice are placed on its surface. They can change the pitch of a recorder or they can change the pitch of a bottle by changing the column of air inside them. It is a good topic for students to find out for themselves—can you make the pitch of an empty bottle change? How can you make a guitar sound louder? They can also investigate hearing. How far do you have to move away from a sound to stop hearing it? Which ear muffs/plugs work best to block out sounds? There are many different investigations that students can do and it is worth considering having students working in small groups to find an answer to a particular question.

Since this unit is about sound it may be useful to focus on the value of verbal communication to scientists. Once they have completed some of their investigations students can share what they have done and what they have found out with the class in a verbal presentation.

YEAR 3

FORCE AND MOVEMENT

Investigating the forces involved in moving

Suggested Time: 9 - 12 hours

Understanding Goals

1. Students begin to understand the importance of moving objects in our lives.
    a. What sort of objects do we use that move?
    b. How have the moving things we use changed with time?

2. Students begin to understand that to make something move requires a force—a push or a pull.
    a. How do we get something to move? How can we make it move more quickly?
    b. How can we stop something moving? How might we slow a moving object down?
    c. What are some of the forces we see at work in our world?
    d. Do these forces have to be in direct contact with an object to produce an effect? Explain.

3A. Students begin to understand the importance of using 'fair tests' to collect information about the effects of forces on objects.
    a. What makes our experiment a fair test?
    b. What information will we collect from the experiment? How will we collect it? How will we record it?

3B. Students begin to understand that scientists often communicate what they have done by writing a report.
    a. What should we include in our report?
    b. How will we know if the way we have written the report is good?

Background Information

Humans are very dependent on moving objects. In early times we made things move by pushing and pulling them ourselves. We provided the push in ancient canoes and we used animals to provide the pull that moved our carts. Later we used the wind to provide the push—the great sailing vessels and windmills both depended on the wind—and we have often rolled things down slopes to move them from place to place. At first we did not understand about the forces that made things move and how these forces worked. It was not until the late 17^{th} and early 18^{th} Centuries that scientists began to understand about the role of forces in movement. One of the great scientists in this area was Sir Isaac Newton whose laws of motion are still relevant today. As we understood more about motion we were able to make moving objects that were more efficient and today we have very sophisticated ways of moving. Despite these sophistications many of the moving objects we use depend on very basic science—pushes and pulls. If we go down a slide we depend on gravitational pull, if we ride a bicycle we create the push that makes the bike move, if we sail a boat we depend on the wind to push us along and if we hit a softball we create the push.

Making something begin to move requires a force (a push or a pull) and creating a force requires energy. We are familiar with the fact that we can create the pushes and pulls needed to make things start to move. Some of these forces need to be in direct contact with the object they are acting on but in other cases forces can act without being in direct contact. A horse needs to be attached to a cart to make it move, but the force of gravity or a magnetic force can act at a distance. The force of the wind can make boats and windmills move and move the washing on the line. We go down a slide and leaves drop off trees because of the force of gravity.

If we create a bigger push or pull we can make things move faster. Once something is moving it will keep moving unless a force in the opposite direction causes it to stop. The surface that an object is moving on produces a force that makes it hard to get things moving or stops them when they are moving. This force is called friction. The air pushes against things that are moving and will cause them to eventually stop. This is called air resistance, it is a type of friction.

You will be able to do many practical activities as students look at the effects of pushes and pulls (forces) on objects. Forces on objects can cause them to start moving, to stop moving, to move more slowly, to move more quickly or to change direction. Small model cars are ideal for students to investigate forces. To start a toy car moving we can push it or pull it. In this case we are providing the force. If we want it to move faster, we need to provide more force by pushing or pulling harder. We can also make a toy car move by putting it on a slope and letting it go. We don't push it to provide the force—the force is provided by the pull of the Earth or gravity. This force is harder to imagine than one we provide ourselves when we make the car move. If we increase the gradient of the slope that the car runs down, we increase the gravitational force and the car will move faster. If the car is made from magnetic material we could make it move by holding a magnet nearby.

If we don't keep pushing or pulling the car it will stop because of friction. Different surfaces create different frictional forces. Rough surfaces will stop the car more quickly than smooth surfaces. If the car hits a wall it will stop suddenly as the wall puts a big force on the car in the opposite direction to which it was moving.

This unit is one where students can co-construct controlled experiments with you and think about what might make them a fair test. For example, if your students test how far cars travel on different surfaces then the surfaces used in the experiment should be the only things that differ—the cars and the force applied to them must be the same (this can be done by letting the cars roll down a slope of the same gradient so that the gravitational force is constant).

The activities in this unit are good for children to learn about writing a report. Make the focus of the report its clarity. Students' descriptions should be clear enough for others to repeat the experiment. First, discuss the report in a communal situation. Try to avoid the traditional words of aim, method, results and conclusion and ask the children to suggest headings, perhaps in the form of questions—What did we want to find out? What did we use? How did we investigate? What information did we collect? How did we record this? What did we find out?

YEAR 4

FRICTION AND MOVEMENT

Investigating the effects of friction on movement

Suggested Time: 9 - 12 hours

Understanding Goals

1. Students begin to understand that friction is both useful and a problem to humans.
   a. In what circumstances do we make use of friction to stop or reduce movement?
   b. When do we want to reduce the friction in objects we use? How do we do this?

2. Students will begin to understand that because of friction energy is needed to keep things moving.
   a. What is friction? What effect does friction have on movement?
   b. How does friction change with the surface an object is on? How does the contact an object has with a surface affect movement? What effect do air and water have on movement?
   c. Where does the energy come from to keep things moving? Is this energy transformed as it moves from object to object?

3A. Students begin to understand that scientists can collect evidence about what happens when energy sources run out by experimenting.
   a. What have we found out from this experiment?
   b. Could we make this experiment better?
   c. Is this experiment a fair test?

3B. Students begin to understand that graphic organisers can be used to make sense of and share information.
   a. How can we sort the information we have learned in this unit to make it clear to both us, and our audience?

Background Information

As humans we often want friction to occur so that the things we use don't slip and slide. Tyres on cars have 'tread' which help keep the car 'stick' to the road, 'Velcro' can be used in lots of situations where we want things to hold together and we put a special material under rugs to stop them slipping on the floor. If there is no friction between our shoes and the surface on which we are walking, we slip—think how difficult it is to walk on ice.

On the other hand, we often want to reduce the friction in the objects we use. If we don't reduce the friction then it is hard to get something to move, it will stop moving sooner and we use more energy to move it. One of the best things humans have invented to help move objects is the wheel. Think about moving a big, heavy box. If you try to push or pull this box it is very difficult because of the friction between the box and the surface it is on, but if you add some wheels to the box it will become much easier to move. The wheels reduce the contact area between the box and the surface and therefore the friction is reduced. Friction also occurs between the medium—such as air or water—an object is in and the object, this is called air resistance and water resistance. To help overcome this resistance to movement and reduce the energy needed humans have designed streamlined objects—think about how the shape of boats, cars and planes has changed over the years. We also know that if we put grease or oil on the moving parts of an object then the friction is reduced—adding oil to the hinges of an old door will make it easier to open and close and oiling a bike chain makes the bike easier to ride.

Friction makes it hard to get something to move and is continually acting to stop an object from moving. The effect of the friction between the object and the surface varies with the type of surface and the amount of contact the object has with the surface. Smooth surfaces will offer least resistance and rough surfaces much more. An object with a large contact area is harder to move than one with a small contact area. The medium the object is in also affects movement. Water is more resistant than air—think about how it is harder to walk through water than through air. The harder it is to get something to move or to keep it moving, the more energy is required. This is why we are constantly trying to reduce the friction in moving objects by streamlining the object, reducing the contact area, keeping surfaces smooth and oiling moving parts.

Creating a push or a pull requires energy and so to start something moving and keep it moving we must keep supplying energy. Often we transfer the energy from one moving object to another to keep it moving. The moving energy of the wind can be transferred to a windmill or to a sailing boat to make it move. These things will slow down and then stop when the wind stops because of friction. In the past, the energy from moving water was transferred to waterwheels to drive mills used for grinding grain into flour. We often provide the energy to keep things moving by transferring our own moving energy to another object such as a bike, a pram or a ball. Scientists call moving energy kinetic energy.

To make things move we can also use energy sources that are not moving, for example, electrical energy and the energy in petrol or food which is called chemical energy. When a car uses petrol to 'go' the chemical energy in the petrol is changed to moving energy in the car. Scientists call the change from one form of energy to another, energy transformation. When we move, the food we have eaten is transformed from chemical energy to moving (kinetic) energy and when we use an electric fan to cool us down in summer, electrical energy is changed to the kinetic energy of the moving fan. As soon as these sources of energy are stopped or run out the movement will stop.

This unit has enormous potential for students to learn by experimenting. They can investigate friction by looking at the effects of different surfaces on movement, they can look at the effect of adding wheels to objects and of streamlining objects. Students can think about or investigate what happens when the energy source for movement runs out—what happens to a sailing boat/windmill/kite when the wind stops blowing, to a battery-operated moving toy when the battery is 'dead', to themselves if they play sport or go to the beach all day without enough food, or if their parents forget to fill the car with petrol? They can experience how their moving energy can be transferred to other things to make them move—ride a bike, push a pram or throw a ball. Ask your children to build a car or to solve a problem such as moving a large box. Search the Internet—there are many activities that can be used in this unit. There are so many activities that it is easy to get side-tracked so you need to keep looking back at the unit Goals and the questions to keep you focussed.

There are many connections to be made in this unit. It is a good one for students to use graphic organisers to sort out, connect and share the information they gain through their activities—graphic organisers such as graphs, tables, mind maps, concept maps, Venn diagrams and various other organising charts.

'I believe that all education proceeds by the participation of the individual in the social consciousness of the race. This process begins unconsciously almost at birth, and is continually shaping the individual's powers, saturating his consciousness, forming his habits, training his ideas, and arousing his feelings and emotions.' John Dewey

THE FUTURE OF aScuPTaS

My hope for aScuPTaS is that it is a beginning not an end of inquiry into the shape and possibilities a science curriculum such as aScuPTaS for primary science teaching might bring. Its evolution is firmly set in my experiences of teaching over many years and its trustworthiness explored in the words of my inquiry, but its future lies with those who might open their hearts and its pages to explore the possibilities further. To add value to my groundwork might require reflection by those who work with aScuPTaS either individually or in a more encompassing project. The opportunities and intentions of these reflections are extensive.

At a personal level reflection might begin with the question at the core of Jack Whitehead's work on personal action research over many years (Whitehead, 1989, p. 41), "How do I improve my practice" of science teaching by using aScuPTaS? Through such reflection primary teachers, especially those who sometimes feel uncomfortable teaching science, are given an opportunity to explore the impact a comprehensive curriculum might have on their confidence and enjoyment of introducing the wonders of science to the children in their care.

To add further value to these personal reflections might require the gathering and interpretation of data collected by individual teachers as part of a more extensive inquiry, perhaps as part of a Master's program, into the role aScuPTaS might play in supporting the development of professionalism amongst primary science teachers in Australia. Others may choose to explore the principles on which aScuPTaS has been built and whether they encourage more children, with different skills, gifts and interests than those who might traditionally choose science, to retain an interest in and add to the depth and understanding of science as they move into their secondary years.

It is with these possibilities in mind that I make aScuPTaS available for research purposes to teachers, both practising and in training, to university educators and to educational researchers. It is for those of us who trust and care 'For those beneath our wings' to plumb the depths of the opportunities aScuPTaS might bring and search, particularly through the use of personal reflective practice, for further support of the authenticity and trustworthiness of my ideas.

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Bloom's Taxonomy, Gardner's Multiple Intelligences and the ideas that have come from the *Teaching for Understanding* project at Harvard have been used to create many materials that can be used in primary classrooms. More information on these can be found on the Internet.

The words I quote from Leonard Cohen come from his song, *Anthem*

All quotes from John Dewey are from "*My Pedagogic Creed* " (1897).