Sci-5: a stimulating start to school science

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Abstract

Stimulating science learning for all children from the start of school is the vision of the Sci-5 professional learning programme. Sci-5 aims to inspire and support teachers to implement a high-interactive science enquiry approach for 5 year-old children in the first year of primary school (Foundation year in Australia). Incorporating early years science education research, Sci-5 was developed over 20 years by an academic teacher-researcher in weekly science classes. The resulting multi-faceted suite of learning experiences and resources were designed and refined in the field. This paper describes the Sci-5 programme, provides key implications for teaching practice, and outlines ensuing research. Dual research aims are to identify teachers' specific professional learning needs to support practical teaching strategies and to enhance the applicability of Sci-5 for use in diverse school contexts.

Keywords: Primary science, enquiry, professional learning, early years, emergent science

Introduction

Every child deserves to experience high-quality science learning at all levels of school. Still, little time is devoted to science learning in pre-schools (Larimore, 2020) and early years science education is lacking, especially in comparison to literacy and numeracy (Roberts, 2021). Young children start school eager to learn in *all* subjects and teachers must avail children of *'their right to engage with the wonders of the natural and designed worlds'* (National Academies of Sciences, Engineering, and Medicine, 2022, p.237). In Australia, most children commence school in Foundation Year as 5 year-olds and their initial experiences provide a pivotal foundation for future learning. This is the age where children's initial views about science and self-perceptions as learners of science form and potentially impact future science-related pursuits (Oppermann *et al*, 2018). I argue that the first year of school is the ideal time to engage children in practical enquiry and inspire a love of learning in science.

Initiatives aimed at increasing interest and fostering careers in science mostly target upper-primary or secondary years. Such efforts are likely too late, because subject perceptions and career aspirations form during early primary school: *'well before a child leaves primary school their "STEM identity" is – or is not – developing'* (Forbes, 2024). The primary school years are crucial in capturing interest in science (Fitzgerald, Dawson & Hackling, 2013) and developing children's science learning trajectories with the narrow achievement gaps (Curran & Kitchin, 2019). Not only is it important that children do science from the start of school, but the learning should also be joyful, engaging and meaningful. Learning experiences in early school science should enable young children to experience the joy and intrigue of science learning as they make sense of the world around them (Earle, 2022). Science surrounds young children in all aspects of their lives; engaging them in exploration and play can aid them to make more sense of their observations. Early years science is important to build a foundation of ideas, language and interest (Earle, 2022) and develop positive dispositions of science (Russell & McGuigan, 2016).

Historically in Australia, science has struggled to be allocated sufficient teaching time in the primary school curricula (Angus *et al*, 2007), in a crowded curriculum comprising six key learning areas: English, Mathematics, Human Society & its Environment, Creative & Practical Arts, Science & Technology, and Personal Development, Health & Physical Education (PDHPE – a mandatory subject). Key issues with children's learning in primary science in England (Bianchi *et al*, 2021) include insufficient timetabling of science time and that young children's curiosity, interests and questions are not being sufficiently capitalised. The Australian Office of the Chief Scientist (2014) advocates *'core STEM education for all students – encompassing inspirational teaching, inquiry-based learning and critical thinking – placing science literacy alongside numeracy and language proficiency as a priority'* (p.20). Science should feature substantially in school curricula to provide balance and to help prepare children for their current and future lives (Stubberfield, 2023). To combat this missed opportunity, regular lessons should be programmed into the weekly timetable from the start of school to ensure that adequate time is given to science learning.

Whilst more science time is pivotal to enhance student learning of science, the curriculum aspects, resource provision, training of teachers and pedagogical approaches are also crucial elements to address. A lack of opportunity for young children to learn science is often blamed on teachers' low science teaching efficacy and limited understanding of science concepts (Roberts, 2021). Primary teachers require support *'to teach science in ways that matter'* to help their children *'better understand why science matters'* (Fitzgerald & Smith, 2016, p.64). Professional learning focusing on science in the first year of school can equip teachers to notice and respond to children's interests, to talk about their ideas and encourage them to think scientifically.

An existing Australian science programme that includes Foundation Year, *Primary Connections* (https://primaryconnections.org.au/) was designed by the Australian Academy of Science to integrate science and literacy. The units of work follow an enquiry and investigative approach incorporating Bybee's 5Es instructional model (Bybee, 1997) and emphasises co-operative learning (Hackling, Peers & Prain, 2007). Primary connections units are ideally taught as complete units, without deviating from the scripted lesson plans, and using the resource materials provided. A strength of *Primary Connections* units is that they provide a fabulous starting point, giving teachers confidence to implement enquiry lessons. A weakness is the view that the literacy emphasis overshadows the science. After using the *Primary Connections* units, many teachers reported (personal communication) the desire to design their own units with greater science practical tasks. The Foundation Year units include some age-appropriate hands-on tasks; however, I recommend a lesson-based, rather than a unit-based, teaching model for emergent science learners.

Sci-5 is a niche programme designed for the first year of school to transition from play-based pre-school to enquiry-based school science learning. Two pre-school STEM programmes include *Conceptual Playworlds*, featured in a previous issue of *JES* (Fleer, 2019, 2022, https://www.monash.edu/conceptual-playworld) and *Early STEM Learning Australia (ESLA*, https://elsafamilies.com.au/). *Conceptual Playworlds* approaches STEM teaching by combining imaginary play with imagination in science and has a strong research basis. Fleer's work on *Conceptual PlayWorlds* (2022) provides insight into ways in which play and intentional science learning can be intertwined. Exploratory play, intentional teaching and interactive dialogue are features of the Sci-5 teaching model that underpin this professional learning programme. The Sci-5 programme is a hybrid of play-based and guided enquiry learning experiences and focuses on high student engagement and emergent science learning, whilst *Early STEM Learning Australia (ESLA)* focuses on digital technologies with play-based digital apps and ideas for off-app activities to help engage pre-school and Foundation Year children in fundamental STEM practices (Lowrie & Larkin, 2022). There are many insights in other documents as well, including the Early Years Learning Framework (EYLF) and Australian research (Australian Government, 2009). This paper will focus on the importance of providing a stimulating science programme for 5 year-olds in their first year of formal schooling.

In contrast to *Primary Connections*, Sci-5 has a flexible design, allowing teachers to choose learning experiences to suit their school's context. The programme adopts a more bespoke approach; for example, one school piloting the programme in late 2023 combined the topics of living things with forces and movement to align with curriculum content in other key learning areas. Enabling teachers to make decisions about sequencing to plan custom units gives them autonomy, respecting their professional expertise and knowledge of the needs of children in their classes. This flexibility avoids a 'one-size-fits-all' approach and aims to inspire teachers to use the example learning experiences to create their own lessons using the Sci-5 teaching model. Teachers in other countries can develop similar learning experiences according to their specific curriculum requirements.

I believe that science must be taught regularly in the first year of school and that teachers should be given support to ensure that it is taught in authentic, effective ways. Science needs to be positioned as an engaging and creative discipline that children cannot do without. Such an aim is ambitious, but achievable. In 20 years of experience as a teacher of science with 5 year-olds, I have collected evidence, from first-hand observations and comparison of pre- and post- work samples, that young children can be fully engaged in hands-on, minds-on science learning from the beginning of school. A targeted approach for thinking about and guiding the science learning of 5 year-olds commencing school is needed.

Background and development of Sci-5

My initial experience teaching high school science with 13-18 year-olds and involvement in curriculum development gave me a thorough understanding of secondary curriculum content. Understanding student thinking and learning in science and an affinity with younger children saw me transition to a science specialist role, teaching all years from kindergarten to upper primary (5-12 year-olds). My passion for science education resulted in a career move to university teaching. I was fortunate to be able to continue weekly teaching at the school, which gave me contemporary classroom experience and opportunity to research my practice as a teacher-researcher. I chose kindergarten because I became enthralled with the perspectives and capabilities of young children at the start of their school learning journey.

I began sharing ideas of practice with teacher colleagues in the profession by writing some articles for *Teaching Science*, the Australian Science Teachers Association journal. In 2016, I was invited to write an Early Years Science feature series to provide hands-on activities to encourage early years children's natural curiosity and develop their scientific thinking. Producing four issues per year (up to 2021) led to a substantial resource base. In consultation with the school principal, we decided that I could make my teaching programme and its multiple classroom-ready resources available for the benefit of other teachers. To assist teachers to understand the research underpinning the teaching programme and become comfortable with implementing the learning experiences in their own classroom, I created the Sci-5 Professional Learning programme.

The first phase in the Sci-5 programme was to consolidate the published articles into an e-book resource to make the work easily accessible to teachers (Figure 1). The learning experiences in the book draw on science lessons conducted between 2003 and 2021. Through practitioner research over this significant time, component activities were extensively tested and iteratively improved, incorporating feedback from multiple practising primary teachers who co-taught the lessons. The e-book, available as an existing resource (at low cost with all proceeds going to the Australian Science Teachers Association (https://www.asta.edu.au/resources/books/), is the centrepiece of the Sci-5 Professional Learning programme.

Figure 1. The e-book resource.

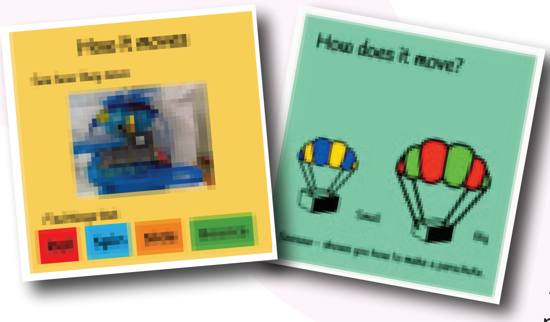
The e-book resource contains teaching strategies, insights into children's thinking, evidence of learning from work samples, and effective and creative ways to explore specific concepts and topic areas. It also includes ideas for practical tasks that teachers can directly use, modify, or be inspired by to create their own learning experiences. The learning experiences in the Sci-5 programme seek to 'push the boundaries' to explore what each child is capable of learning so as not to be superficial, to extend children's thinking and motivate them towards working scientifically (Bianchi *et al*, 2021). Table 1 lists the articles grouped by science domain and shows the range of topics included. The learning experiences comprise three to four per science area, two that focus on STEM and on technologies (design and digital), and four that target development of enquiry skills practices.

Table 1. Structure of the professional learning resource.

Science Domain	Number of articles	Content inclusions
Biology	4	Model animal habitat, Plant leaf exploration, Food from plants, Reasoning about living things.
Chemistry	4	Water wonder – online learning, Material properties, Weaving fabric, Materials testing umbrella.
Earth Science	3	Clothes for different seasons, Simple wind detector, Rock wonder.
Physics	3	Parachute drop, Lego car race, Moving toys.
STEM	2	STEM torch design, STEM scooter design.
Enquiry skills practices	4	Observing using the senses, Drawing like a scientist, Magnify me, Child-led inquiry.
Technologies	2	Digital technologies, Design a bookmark.

The Sci-5 programme also includes other resources to support teaching and learning in specific topic areas such as: interactive e-books for children (Figure 2), videos for teachers, lesson plans and examples via the See Saw e-learning platform.

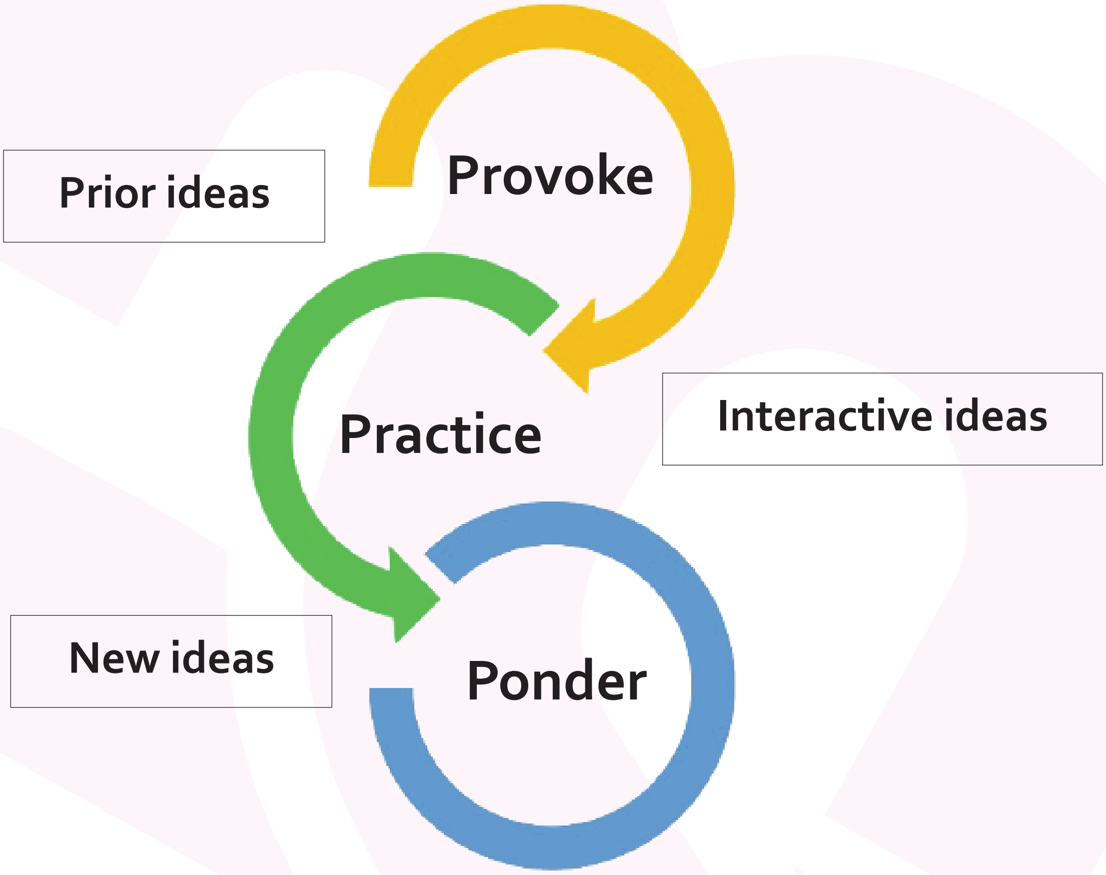
Figure 2. Sample e-book pages.



The Sci-5 teaching model

My approach to teaching science to 5 year-old children '*is grounded in a constructivist, hands-on, minds-on, view of learning*' (Preston, 2022, p.4). My practice draws on 25 years of research in science education informed by my co-edited book *Teaching Primary Science Constructively* (Skamp & Preston, 2021). Through progressive implementation of research on early years science in my classroom, with input from experienced kindergarten teachers, I developed a Sci-5 teaching model on which the learning experiences in the programme are based (see Figure 3).

Figure 3. Preston Sci-5 Teaching model.



The learning experiences were created to draw on children's existing ideas as the foundation for additional learning. Each lesson commences with a **provocation,** such as a question, physical resource, puzzle, or story to trigger prior knowledge and pique children's interest. Acknowledging that 5 year-olds will come to school with previous learning such as pre-school (EYLF, Australian/ Early Years Foundation Stage, in England) and from personal experiences growing up in their world, this stage engages children in voicing their ideas and thoughts, evoking Russell and McGuigan's (2016) view that '*teaching is an interactive pursuit, something done with children rather than to them*' (p.3). This helps teachers to gain insights into children's thinking, to see the world from immature, novel perspectives and to build learning experiences around their emergent science learning.

Most of the lesson time is taken up with **practical** tasks, through which children can explore, discover, create and test their ideas. Through hands-on investigations, children expand their ideas, develop scientific skills, and are challenged to think like a scientist. Throughout the interactive dialogue between children and teacher, they are encouraged to ask and answer questions, which supports their meaning-making. In this way, the children develop understanding of science concepts as they engage in doing science.

The final phase of the learning experience provokes children to **ponder** what they have learnt: voicing new ideas helps to consolidate their shared and individual learning. Children may exhibit and talk about the products of their work and express interest in future directions of learning. Key implications for practice of the Sc-5 approach are summarised in Table 2.

Table 2. Summary of Sci-5 with implications for practice.

Key implication	Practice notes
Provoke – start each learning experience in interesting, engaging ways that activate thinking and elicit children's prior ideas.	Use a stimulus to gain children's attention
	Focus children's thinking on the topic/concept/ problem
	Ask questions to encourage children to express their ideas and consider other people's ideas
	Engage children in preliminary discussion
Practice – include one or more hands-on experiences as essential learning elements. Support children to develop skills and create meaning as they explore and investigate science topics.	Engage children in different practical experiences
	Provide new and repeat opportunities to develop scientific skills and practices
	Support children's thinking and noticing during practical experiences
	Develop sharing, turn-taking and helping each other
	Enable children to do and think like scientists
	Support children to record and communicate ideas using age-appropriate, multi-modal strategies
	Have children generate meaningful representations using drawings and annotations
Ponder – consider the learning from the children's perspective. What do they know, think, or can do now? Where to go from here?	Encourage children to reflect and talk about any new ideas
	Reinforce big idea(s) related to children's learning
	Encourage wonder and to ask further questions

Age-appropriate hands-on tasks

I feel that the strongest element of the Sci-5 programme is the range of hands-on practical tasks suited to 5 year-old children. Every activity has been refined over many years of collaboration with kindergarten classroom teachers. Although teachers may be willing to implement practical enquiry, the challenge is to find tasks that have been specifically designed for emergent science learners. One of my favourite tasks involves children building a Lego car and using paddle pop sticks to measure how far the car goes to answer a question such as: Which wheels make the car go further? Figure 4 shows two girls working together to measure how far the car moves and Figure 5 shows the scaffold to guide children in their first recording of results by colouring in the boxes to represent paddle pop sticks.

Figure 4. Children measuring using pop sticks.

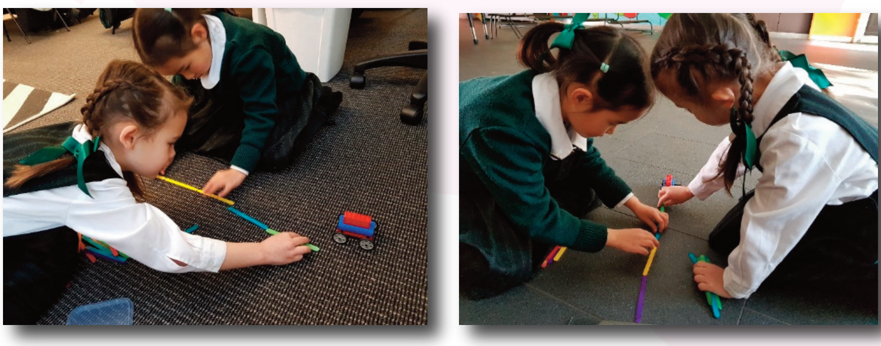
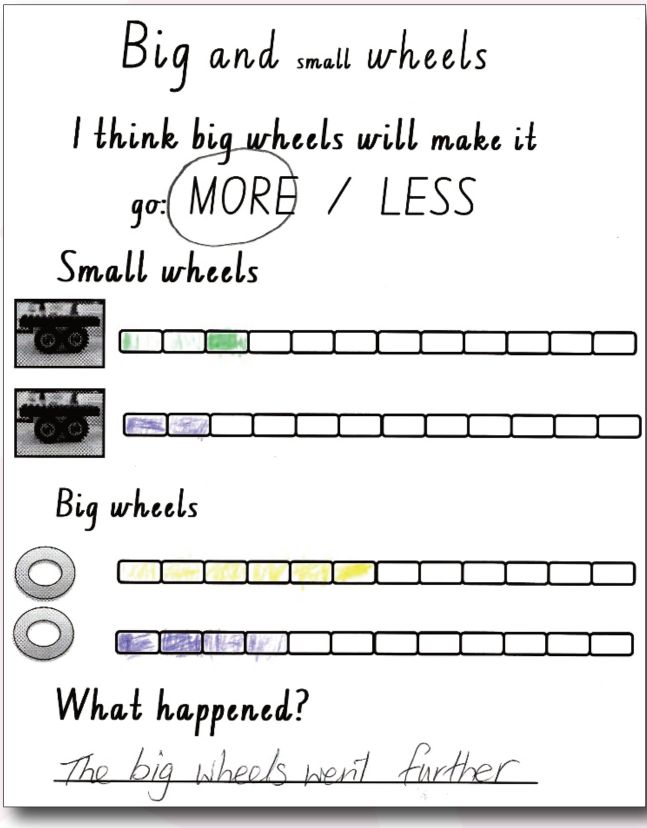


Figure 5. Sample pupil record.



Physical equipment / resources

A range of equipment is needed to implement the learning experiences. It is my belief that you 'can't teach science without stuff'. Fortunately, most of the equipment can be easily sourced and I recommend building up a store of materials that can be used regularly for science lessons. Some teachers whom I have mentored created a 'storeroom' out of disused lockers, which were transformed into a shareable resource space (Preston & Mussone, 2013).

Examples and modelling

As the Wellcome Trust's research reminds us, some teachers *'do not see themselves as 'sciencey'* (Wellcome, 2020, p.9), hence the need for a range of support materials within the programme resources. For example, quotes direct from children in my classes and work samples provide teachers with insight into 'where children are at' in their learning trajectory in their first year of school. Of course, every class is different and learning experiences may need to be adapted to suit the specific learning needs of each group of children. My experience is that the example learning tasks can be adapted to be variously challenging and to be inclusive. A few videos are available that provide opportunities for teachers to view teaching strategies first-hand. For example, a video taken while I was teaching kindergarten how to draw like a scientist (https://youtu.be/S-j_3r4v8vk) demonstrates the use of embodied learning. Gestures and acting out 'tracing the plant in my mind' are demonstrated, together with the children's reactions to my deliberate mistakes. Recent research in informal science centres (Manches & Mitchell, 2023) and my own research in mathematics and science (Preston, Way & Smyrnis, 2022) demonstrate the *'embodied nature of how we think, and the potential to encourage body-based experiences to support learning'* (Manches & Mitchell, 2023, p.23). Viewing examples of practice is a good way to help teachers to see possibilities for teaching kindergarten science.

Current and future research

My kindergarten science teaching experience enabled me to develop a suite of practical learning tasks to connect with the children's lived experiences and stimulate interest in science, but this requires testing in other classrooms to validate my belief that the Sci-5 model is a valid approach to science education in the first year of primary school. The question is whether these resources are useful to support other teachers to adopt and enhance a guided enquiry approach. To provide a strong evidence base for teachers to modify their practice, there must be a clear understanding of their perceived needs, readiness and suitability of support provided (Deehan & McDonald, 2023).

The following research questions focus this enquiry:

1. What are the specific professional learning needs of teachers to develop a child-focused, practical enquiry approach to science in the first year of school?
2. How do teachers perceive the applicability of the Sci-5 resources and learning experiences for their school context?
3. To what extent do the learning experiences engage children in active enquiry learning in science?

The first part of the research (phase 2 of the programme) involves piloting the Sci-5 professional learning in schools with multiple kindergarten teachers to gain feedback on how the resource materials need to be adapted for use by different teachers in a range of school contexts. Two schools participated in the Sci-5 programme in the final school term of 2023. Initial responses from teachers in the pilot phase in 2023 include being delighted about the extent of high-level engagement of children throughout the lessons, and surprise about their prior knowledge of science ideas.

The findings of phase two will inform further development of a Sci-5 professional learning package. In the second part of the research (phase three), the professional learning package will be implemented in a broad range of Australian schools with data being collected on its impact on teaching. Future research may also consider the long-term impact of the Sci 5 programme on children's primary school science learning because of experiencing a stimulating start to school science.

Table 3. Research project phases and timeline.

Phase and year	Details
1– 2022 Resource development	Development of support materials for teachers including publishing an e-book of research-based teaching activities.
2 – 2023-4 Pilot	Test and revise the resource materials and professional learning strategies to enhance applicability for use in diverse school contexts. 5 schools (city and country), 16 teachers (class and specialist).
3 – 2025-6 Upscaling	Implementing the professional learning package in a wide range of schools and evaluating the impact on teacher practice. 30 schools (city and country), 120 teachers (class and specialist).

The aim of the three-phase project is to develop an evidence-based, classroom-ready professional learning package that empowers teachers to implement constructive pedagogy that supports contemporary practice in science teaching and learning in the first year of school. The research is significant because, whilst we know that primary teachers want professional learning, their specific needs in relation to teaching science in the first year of school are unknown. Rarely are teachers provided with in-class teaching support and the opportunity to experience and adapt resources to suit both their teaching and the learning needs of their students. It is hoped that the research will provide insights into factors that will enhance the uptake of professional learning for teaching science and the benefits for 5 year-olds of a stimulating start to school science.

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