Communicating science to the very young through play: The Kia Rapua Science Playground project.

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Introduction

Early childhood interactions with science shape young learners' self-conceptions and aspirations in science, as well as facilitating the development of skills that give long term learning advantages (Archer et al., 2013; Eshach & Fried, 2005; Morgan, Farkas, Hillemeier, & Maczuga, 2016; NSTA, 2014; Trundle, 2005). Science achievement gaps can develop at preschool age and persist for many years (Morgan et al., 2016), with poor performance in primary schools seemingly having its roots in the preschool period (Greenfield et al., 2009).

The amount of science taught during the early years of education lags behind other subject areas (Greenfield et al., 2009; Morgan et al., 2016; Saçkes, 2014). Evidence suggests this is as a result of barriers such as early childhood educators' low self-efficacy in teaching science and/or time constraints or dearth of suitable materials. Educators report feeling less prepared and competent to teach science compared to other areas and lack confidence due to perceived low science knowledge (Greenfield et al., 2009; Kallery & Psillos, 2002; Timur, 2012). A key intervention identified by Greenfield et al (2009) is to provide direct support to educators so they more competent in teaching science, and to help them integrate other aspects of learning into science activities. Scientific inquiry in the preschool setting develops skills such as building vocabulary, communicating, predicting, counting, measuring, drawing objects, using fine and gross motor skills and working in groups. Thus it provides a valuable opportunity for teaching across all domains of learning.

Developing programmes for engaging young children in science must take into account the nature of how these children learn, proven effective teaching strategies and the role of the adult or educator in guiding learning. Interestingly, evidence has demonstrated that very young children are cognitively capable of hypothesis testing and causal inference, key aspects of scientific thinking (Gopnik, 2012; NSTA, 2014). Science for this age group should provide appropriate environments for further development of these reasoning and inquiry skills, including hands-on experiences and meaningful activities relevant to children's daily lives, so they can scaffold on existing knowledge and reinforce this knowledge across time and in different contexts (Greenfield et al., 2009; NSTA, 2014; Trundle, 2005; Worth, 2010). Adults play a crucial role in guiding learning for young children (Bulunuz, 2013; Henderson & Mapp, 2002; Patrick, 2017, Chapter 11; Yoon & Onchwari, 2006). Explicit teaching or explaining 'how something works' narrows the range of hypotheses children consider. '*Activities such as encouraging play, presenting anomalies, and asking for explanations prompt scientific thinking more effectively than direct instruction'* (Gopnik, 2012, pg1627). Instead the adult should guide learning through focusing children's observations, structuring the learning experience and regulating the difficulty of the information level.

Despite the obvious benefits of science engagement at this early age and the ongoing barriers to educators, this continues to be an area that is poorly targeted by informal science education initiatives in New Zealand. Here we describe the Kia Rapua/Go Explore – Science Playground pilot project aimed at very young learners (2-5 years old) and their carers. The main aim of this project was to empower early childhood educators and parents to guide the development of the scientific thinking of the young children in their care. To do this the project made use of educator workshops,

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family accessible activities, and developed a mobile science playground as a physical framework to encourage scientific exploration for this age group. This pilot project was funded by the New Zealand Government's Unlocking Curious Minds initiative (https://www.curiousminds.nz/).

Project stages

The core idea behind the Kia Rapua Science Playground project was to create a playful environment that fosters scientific thinking by giving young children, and their caregivers, the ideas and materials to exercise their natural curiosity. Four local preschools in the city of Dunedin, New Zealand partnered with the project. The main project stages were:

1. Early Childhood Science workshop
2. Playground conceptualization and development
3. Public events
4. Playground tour of partner preschools
5. Playground webpage with science activity resources

1. Early Childhood Science workshop

A total of 15 preschool educators and parents from 3 partner preschools and one partner playcentre attended workshops run by two science communication professionals. The workshops dealt with the nature of science and the scientific method and how science can be incorporated into other activities such as art, cooking and sports. They also touched on the research behind how young children of this age learn and asked teachers to design a simple science activity that they would then run with the children in their care. Discussions of educators' experiences of running science activities with this age group were key for the next phase of playground development as well as for peer sharing.

2. Playground conceptualization and development

In New Zealand, the early childhood curriculum Te Whāriki is made up of 5 mains strands, one of which, Strand 5: Exploration/Mana aotūroa (pages 46 - 50) links to development of science skills and thinking (Ministry of Education, 2017). In addition to aligning with the goals of Te Whāriki we took into account previous observations on creating science inquiry activities for young learners that highlight three important criteria – that the material for study must be drawn from the environment in which the child lives, that the activities are underpinned by important scientific concepts and that the topic is rich in opportunity to be developed in depth over time and in different contexts (Worth, 2010). Five playground displays were created based on the themes of 'I can see', 'I can hear', 'I can touch', 'I can build' and 'I can move' (Figure 1). These five themes were then used to address the specific science concepts of light, sight and colour, sound, vibrations, pitch and volume, sensations, textures and skin, water properties and engineering and gravity, friction and motion.

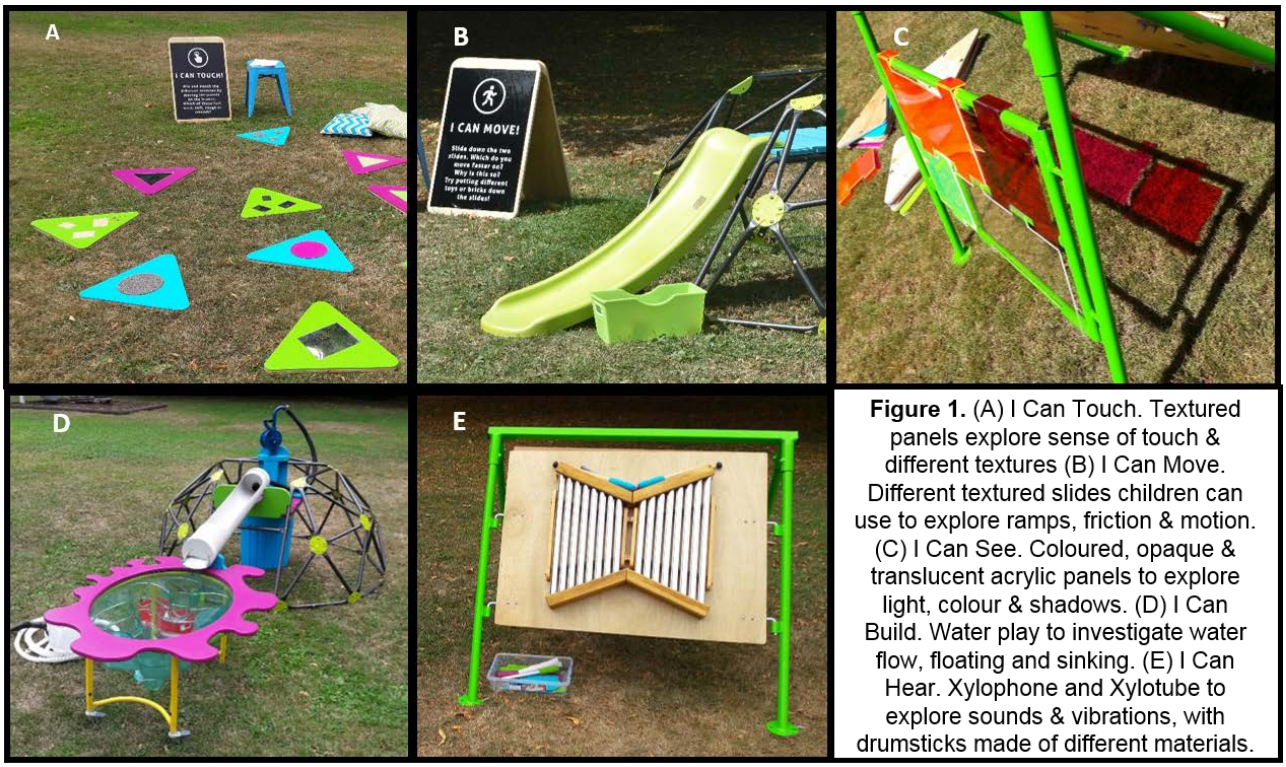

Figure 1. (A) I Can Touch. Textured panels explore sense of touch & different textures (B) I Can Move. Different textured slides children can use to explore ramps, friction & motion. (C) I Can See. Coloured, opaque & translucent acrylic panels to explore light, colour & shadows. (D) I Can Build. Water play to investigate water flow, floating and sinking. (E) I Can Hear. Xylophone and Xylotube to explore sounds & vibrations, with drumsticks made of different materials.

3. Public events

The playground was launched on the grass reserve space outside the Otago Museum in Dunedin at a weekend public event where families were invited to bring their young children to try out the playground and associated activities. The playground was also brought to the New Zealand International Science Festival Kindergarten morning. Do-it-yourself at home science activities guides were available on the day and online (http://otagomuseum.nz/learn/kia-rapua/for-parents/). Science communicators and instruction boards were also present to help guide inquiry based play. Across the two public events 410 people engaged with the playground.

4. Playground tour of partner preschools

The playground and associated equipment was brought to four partner preschool centres and spent a month at each centre. Activities to do in preparation for the playground and science activities to do with each playground interactive, based on the different science concepts and themes, were made available online (http://otagomuseum.nz/learn/kia-rapua/for-educators/). Across the four playcentres a total of 261 children and 32 educators engaged with the playground.

5. Playground webpage with science activity resources

A Kia Rapua website was developed with separate sections for parents and for educators (http://otagomuseum.nz/learn/kia-rapua/). On these different webpages science activities were available for download, to be done by families at home (for parents) or to be done in a preschool setting either with or without the playground facilities. Online engagement with the do it at home science activities was encouraged by use of a competition.

Project evaluation results

Both quantitative and qualitative methods of evaluation were used throughout the different project stages. Pre and post questionnaires were given to preschool educators involved in the project at both the workshop and playground tour stages. Feedback questionnaires were used to survey families that attended the public launch and science festival events. Facilitators' observations were gathered during the workshops and the public events, and discussions with educators at playground collection allowed gathering of verbal feedback on playground use.

Educators attending the workshop (15) had varied levels of experience from 0 (student) to 30 years. They reported running science activities with the children in their care an average of 2.2 times per week, with the range being from once a month to once a day. When asked about difficulties in running science activities educators identified engaging mixed ages of children as a key difficulty along with lack of resources and ensuring the information is pitched at an age-appropriate level.

On post workshop evaluation, educators were positive about the content and structure of the workshop. Educators and facilitators both felt that a key element to the workshops was the exchange of information and ideas and the discussions based around incorporating simple science and the scientific method into everyday activities. A key observation at the workshop by facilitators was the narrow concept that educators had about what science is and what science activities entail. This narrow idea that adults may hold about science, rather than science as a way of thinking or understanding the world has been commented on previously (Castell et al., 2014; Hobbs, 2015). After the workshops the educators recognized the inherent science in many activities such as cooking, art and sports and how experimental thinking and the scientific method could be introduced to these activities using simple, basic resources. When asked what they liked best about the workshops one commented on the *'Fantastic practical ideas about linking key scientific concepts to everyday activities and play'.*

Educators were asked to rate their confidence levels in four aspects of delivering science to this age group both before the workshop and at the end of the project. The results are shown in Figure 2. A shift in confidence levels is evident in this pre and post comparison, especially notable for the aspects of 'developing new science activities' and 'your science knowledge'. However it must be noted that number of respondents is low (pre n = 15 and post n = 8) and it cannot be determined that the shift seen is not due to other factors outside of involvement with the Kia Rapua project. In post project surveys the workshop training was acknowledged as being a key part of the project that helped to prepare educators, '*Thanks for the opportunity to participate - to replicate the opportunities 'Kia Rapua' gave children in our centre would have been hugely demanding in terms of time, resource and expertise. The training was instrumental in the success of the project, giving teachers confidence and enthusiasm to take part.'*

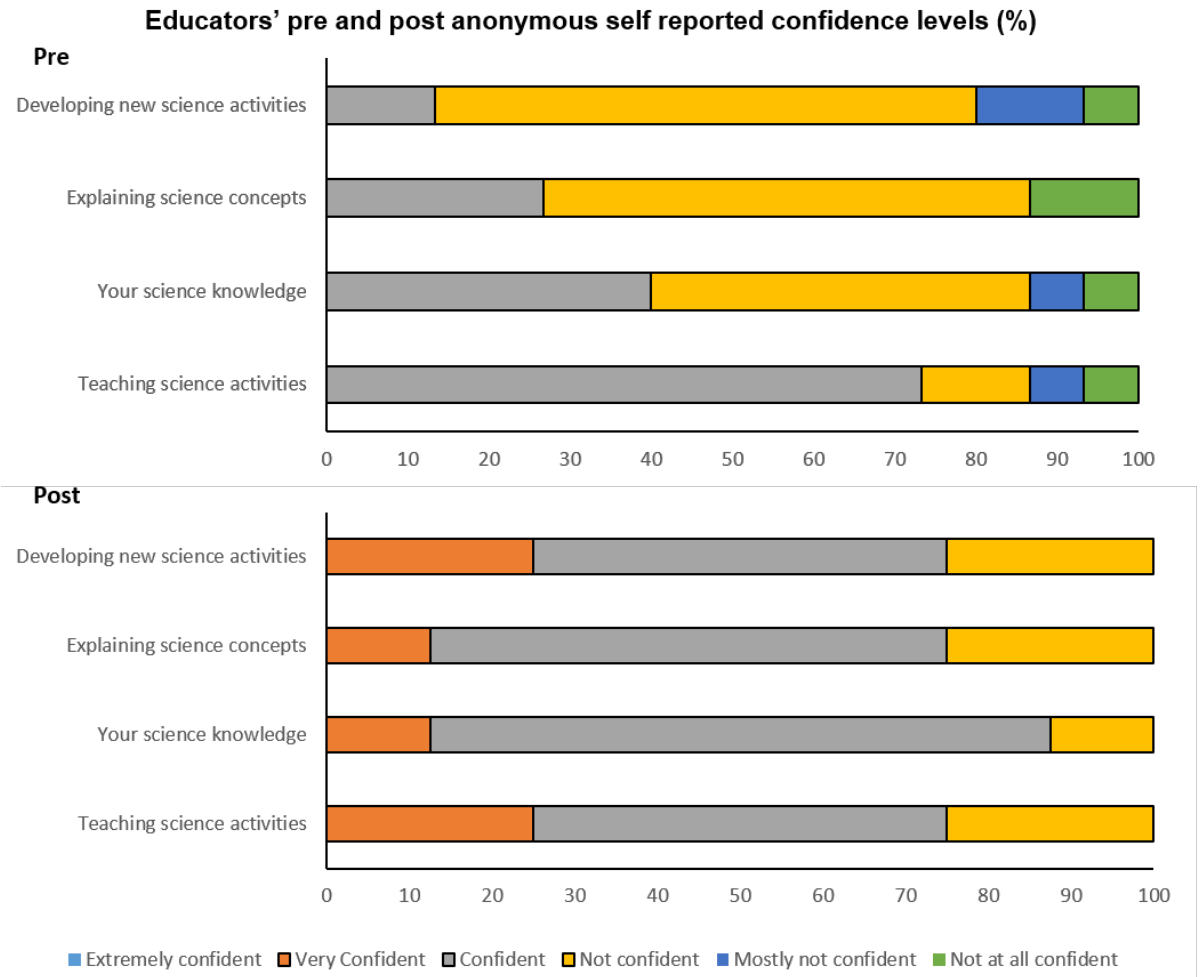

Figure 2. Pre and post self reported confidence levels of preschool educators. Educators were asked to rank their confidence levels on a 6 point Likert confidence scale with regards the four aspects listed before participating in the workshop at the beginning of the project and after having the playground in their preschool. Pre n = 15, post n = 8. Results displayed as a percentage of responses.

The playground was received positively by the public. 60% of respondents selected 'Loved it' when asked what they thought about the experience, with the remaining 40% selecting 'It was ok', no respondent selected 'Didn't like it'. Several comments asked for a permanent installation of the playground while others were positive about the fact that it was aimed at a younger age group *'Great to see something specifically for under 7's!'.* At these public events, facilitators observed a marked difference between engagement of the children with the playground depending on if they engaged in free play, or guided play. Suggestions of inquiry based play for each playground structure were given on boards placed next to the structures and science communicators were present to direct either the children's play or the parent's questioning. Parents were more likely to give feedback indicating that the playground was '*too simple'* or *'unsuitable for older children'* if they or their child were not engaged by a science communicator and were less likely to agree that their child *'learned a lot'*. This key learning echoes reports in previous work (Hobbs, 2015; Patrick, 2017; Trundle, 2005). With play alone children have only a very superficial engagement, development of scientific thinking requires guidance and focus from an adult.

Preschool educators returned positive feedback in post playground tour questionnaires with regards the open ended nature of the playground and the helpfulness of the activities and information provided. They also gave positive verbal feedback and supplied extra written feedback and picture reports showing child engagement with the playground and development of scientific

thinking (see Figure 3). Educators liked the open-ended, simplicity and hands-on nature of the playground interactives but also highlighted the completeness of the project as a whole package. *'Kia Rapua came to us 'ready to go' physical resources as well as training and written plans and supporting information. It was perfectly pitched for our children, linked to curriculum, & easily accommodated within our centre footprint. It was attractive to children and very hands on. Plain language explorations of science concepts and great resources for all teachers regardless of whether they have prior knowledge.'*

Figure 3. Photograph evidence provided by preschool partner showing children using the playground equipment to A. Explore similar textures and B. Test hypotheses about different textured slides.

Conclusions and future directions

Preschool science education for young children allows development of skills that will help them in future learning, as well as self-aspiration in science. However, preschool science is often overlooked due to parents' or educators' perceived difficulty of creating or running science activities and lack of confidence in science knowledge.

The Kia Rapua Science Playground project described here provides a platform to engage younger children and their educators in science activities. The advantage of the playground and associated activities is that it provides resources ready to go to preschools. However, a key learning from this project is the importance of adult or educator guidance of learning when engaging young children in science activities. Future projects aimed at young children should ensure to include opportunities to engage their carers to help them develop guidance and questioning techniques to further their child's science explorations.

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