# The quality of teacher-child interactions during the enactment of playful science games in preschool

*Research Findings:* This research aims to examine the affordances for high quality instructional support offered by the Northern Territory Preschool Science Games, alongside differences between classroom quality during the enactment of this teaching resource and the broader early childhood program. Applying a multiple case study approach, quality was measured via classroom observations in three preschools at two points, teacher interviews on science practice were thematically analyzed and content analysis was conducted to determine the instructional support affordances of the Northern Territory Preschool Science Games. Results demonstrated that the games most frequently offer affordances for concept development interactions, in particular analysis and reasoning. Further, classroom observations revealed that instructional support quality was higher during the time teachers enacted a Northern Territory Preschool Science Game compared with the broader early childhood education program. In line with the primary affordance of the games, there was also a marked increase in concept development during these periods. *Practice or Policy:* These findings suggest that this science teaching resource provides a supportive structure for teachers to transform pedagogical prompts into teaching practice.

Keywords: preschool; science; classroom quality; instructional support; teacher-child interactions

## Introduction

Early childhood educators increasingly recognize children’s natural curiosity about water, plants, insects, animals and what happened to the dinosaurs as scientific thinking (Eshach & Fried, 2005; Inan, Trundle, & Kantor, 2010). In the home and community settings, new technologies and sustainability practices create unique opportunities for parents and children to develop and apply scientific thinking in meaningful, everyday scenarios (Hassinger-Das, Bustamante, Hirsh-Pasek, & Golinkoff, 2018). In turn, there is a growing focus on the inclusion of opportunities for young children to explore science, technology, engineering and mathematical thinking in play-based, early childhood curricula. Further afield, national science and innovation agendas (Commonwealth of Australia, 2015) are influencing state and territory educational policies (Department of Education, 2018). These interacting layers of influence within the child’s learning environment in turn aim to foster the children’s interest in science, strengthening the importance to support science learning in early childhood.

The attention now being given to science in early childhood education necessitates examination of how best to encourage this curiosity and to support children’s playful scientific exploration. For early childhood educators, as intentional practitioners, there is a need to be purposeful in the planning of the curriculum and the resources made available to children to explore. In addition, educators plan how they will join in with children’s play and at times, how they will introduce new ideas that extend what children already know. Here, we argue that science exploration in the context of early childhood education should focus on science process skills – skills such as observing, classifying, predicting and checking. These skills are the basis of scientific thinking, where by one coordinates “theory and evidence in a consciously controlled manner” (Kuhn & Pearsall, 2000, p. 114). As a child becomes skilled in scientific thinking through applying science process skills, they combine observations with existing understandings to create new knowledge in a metacognitively controlled process (Kuhn, 2000). It is the metacognitive development attained through playful exploration of the science process skills, with the support of an attuned early childhood educator, that enables children to transfer and apply these skills to other topics of interest (Kuhn & Dean, 2004).

The Northern Territory Department of Education has committed to building teacher capability and student engagement in science, technology, engineering and mathematics (Department of Education, 2018). In this paper we investigate the enactment of the newly developed *Northern Territory (NT) Preschool Science Games* (Author, 2018). These games are a part of a freely available suite of science, technology, engineering and mathematics resources for educators that apply a science process skills approach to scaffold scientific thinking, analysis and reasoning. Further, the games aim to support educators to extend children’s language and participation in science education by making connections between playful explorations in the early childhood education setting and the world around them. This study examines the impact of the NT Preschool Science Games on measures of classroom quality. In particular, it aims to identify the affordances of the games for increasing instructional support. Here, ‘affordances’ refers to opportunities and prompts for instructional support provided by the games. Further, classroom quality across the morning program, which included the enactment of the games, will be explored to determine any differences in observed quality across the program. Specifically, the research questions addressed are:

1. What affordances for instructional support interactions are provided by the NT Preschool Science Games?
2. What are the differences in classroom quality during the enactment of an NT Preschool Science Game compared with the broader early childhood program?

## Background

When investigating the impact of early childhood science education on children’s learning outcomes, the quality of teacher-child and peer interactions must be considered since interactions with adults and with peers support learning (Burchinal et al., 2008; Howes et al., 2008; Mashburn et al., 2008; Pianta, Barnett, Burchinal, & Thornburg, 2009). Quality measurement is complex, with available measures predominantly focusing on domain-general characteristics of quality including staff demographics, educational resources and the nature of interactions between children and educators (Ishimine & Tayler, 2014). These domain-general measures can be applied across settings and contexts. This is an emerging area of research as instruments to measure both children’s science outcomes (Brenneman, 2011; Greenfield, 2015) and domain specific measures of science teaching quality (Brenneman et al., 2011) are limited.

The Classroom Assessment Scoring System (CLASS) is a validated measure of teacher-child interactions (Pianta, La Paro, & Hamre, 2008). Teacher-child interactions are assessed at the classroom level across three domains: emotional support, classroom organization and instructional support. Teachers who provide a high level of instructional support are those who apply strategies to encourage children’s higher order thinking skills by prompting children to explain their thinking or by asking open-ended questions, who extend children’s language skills and who give specific, timely and process-oriented feedback (Burchinal et al., 2008; Pianta & Hamre, 2009; Pianta et al., 2008). Acknowledging the diversity of curricula and frameworks relied upon in early childhood settings, the CLASS instructional support domain takes an agnostic approach by focusing on cognitive and metacognitive skills that support children’s academic development (Pianta & Hamre, 2009) rather than subject-specific content.

Over the past ten years, research on classroom quality using CLASS has investigated first, potential thresholds of quality and second, possible upper and lower limits to the impact of quality on child outcomes (Burchinal, 2010; Burchinal, Vandergrift, Pianta, & Mashburn, 2010; Hatfield, Burchinal, Pianta, & Sideris, 2016). Work to date has identified no point at which increasing quality ceases to impact child outcomes (Zaslow, Burchinal, Tarullo, & Martinez-Beck, 2016). Whilst researchers are yet to reach a consensus on a baseline threshold for quality to impact child outcomes (Burchinal et al., 2010; Hatfield et al., 2016), results from a meta-analysis of the field suggest that for instructional support quality to be associated with gains in child outcomes, it must be maintained in the moderate to high quality range (Burchinal et al., 2016; Zaslow et al., 2016).

Research suggests that whilst instructional support is associated with gains in child learning (Mashburn et al., 2008), it is a characteristic of high quality pedagogy with which early childhood practitioners in Australia require the most support (Tayler, Ishimine, Cloney, Cleveland, & Thorpe, 2013). Examination of the effectiveness of instructional support interactions has identified that, instructional teacher-child interactions are not supported equally in all academic areas (Cabell, DeCoster, LoCasale-Crouch, Hamre, & Pianta, 2013; Kook & Greenfield, 2020; Thorpe et al., 2020). In an exploratory study of 314 preschools in the US, the quality of interactions between teachers and children was measured using CLASS (Pianta et al., 2008) during specific classroom social exchanges and learning activities including meals, routines, literacy, math, science and numerous others (Cabell et al., 2013). Whilst the overall level of instructional support quality was low, teachers demonstrated the highest level of instructional support quality while interacting with the children in science learning experiences in both large groups and free choice settings (Cabell et al., 2013). Focusing on teacher directed activities, Kook and Greenfield (2020) examined teacher child interactions during storybook reading, mathematics, science and circle time. Again, they found the overall instructional support quality was low, however quality was relatively higher during the science and storybook reading conditions. This body of research suggests that science learning experiences provide the context for higher quality teacher child interactions that support children’s higher order thinking skills, expand their learning and use an extended range of vocabulary (Cabell et al., 2013; Kook & Greenfield, 2020; Thorpe et al., 2020).

Research from the United States, and more recently Australia, has identified the amount of time dedicated to science education in early childhood programs is limited (Early et al., 2010; Harrison, Wong, Press, Gibson, & Ryan, 2019). Whilst an increase in the quality of teacher-child interactions during science learning experiences has been identified (Cabell et al., 2013; Kook & Greenfield, 2020; Thorpe et al., 2020), contrasting research evidence suggests that when science learning opportunities are available, teachers rarely interact with children to facilitate and extend their learning (Gelman & Brenneman, 2004; Nayfeld, Brenneman, & Gelman, 2011; Tu, 2006). This situation is likely compounded by low levels of instructional support in Australian preschools (Tayler et al., 2013). Supporting teachers to engage in extended interactions with children in science contexts may be one way to begin to address the level of instructional support quality in Australian preschools.

The Early Years Learning Framework for Australia (Department of Education Employment and Workplace Relations, 2009) promotes a process skill approach to early childhood science education. The framework guides teachers to develop an informal curriculum that supports children to “develop a range of skills and processes such as problem solving, inquiry, experimentation, hypothesising, researching and investigating” (Department of Education Employment and Workplace Relations, 2009, p. 38). Specific science content areas for teaching are not prescribed within the framework. Science in early childhood goes beyond the rote teaching and learning of content knowledge (Andersson & Gullberg, 2014). Early childhood science education is contextual and reliant upon multiple factors including the child’s interests and the teacher’s notion of science (Siry, 2014). By fostering scientific process skills that include observing, comparing, classifying, predicting and checking, and communicating and recording, the focus of science teaching is shifted from content knowledge to process skills. Cultivating these science process skills within scientific contexts ultimately leads to the development of content knowledge (Jirout & Zimmerman, 2015; Zimmerman, 2000). Further, this allows for science process skills to be applied in an endless number of contexts, providing the children with boundless opportunities for science learning.

In this study, we were interested in understanding the opportunities for instructional support interactions offered by the NT Preschool Science Games. Further, we sought to examine the effect of preschool teachers’ enactment of one science game on the quality of instructional support observed across a typical early childhood program.

## Materials and methods

Bronfenbrenner’s (1977) ecological system’s theory provides the framework within which the teacher-child interactions in early childhood science education will be examined. A nested arrangement of systems (the micro-, meso-, exo- and macro- systems) make up the ecological systems environment. Here, the teacher (in preschools attached to schools) or lead educator (in long day care services) is situated in the child’s microsystem and has a proximal influence on child outcomes. This positioning allows for the investigation of complex relationships between the teacher and multiple settings, including the teacher-child interactions within the context of science education. Taking a multiple case study approach (Yin, 2009, 2018) facilitates the examination of proximal influences on individual teachers and educators who play a key role in a child’s microsystem. Their position in the child’s microsystem establishes teachers as the primary influencers of classroom quality, which in turn is associated with child learning outcomes. The multiple case study approach adopted in this study allows for the replication of cases across early childhood service types and locations (Yin, 2009).

This research received University ethics approval (REF:1853428.1) and permission to conduct research in preschool and long day care settings in the Northern Territory (NT), Australia (REF:14707). Purposive selection was used to define and locate eligible participants (Morgan, 2017). To enable preliminary systematic comparisons of the data and replication of cases, two participants were recruited for each type of setting (Yin, 2009). Selection criteria included:

1. A teacher or lead educator responsible for curriculum planning and assessment;
2. Currently teaching children aged 3- to 5 years attending a long day care program or preschool program;
3. Preschool or long day care service located in a capital city or a regional town;
4. Willingness to delay use of the NT Preschool Science Games until the commencement of the research.

First, a list of all long day care services and preschools in the capital city and a regional town, was obtained from the NT Department of Education (DoE). In the NT, preschools are typically co-located with primary schools, whereas long day care services are typically ‘stand-alone’ services. One point of investigation related to the influence of long day care versus preschool education. Consequently, long day care services were excluded from this list if they were co-located with a school due to the perceived influence the school environment may have on the teaching and learning that occurs at these services.

During the design-trial-refine process, the NT Preschool Science Games had been trialed in services across the NT in 2018 to ensure that the games met teachers’ needs. Consequently, preschools that had contributed to this process were excluded. The remaining long day care services and preschools were sorted by location, then service type and randomized. Preschools and long day care services in the capital city and regional town were sent introductory emails to determine their interest in participating in this project. In total, 2 preschools and 2 long day care services in the capital city, and 2 preschools and 1 long day care service in the regional town, provided informed consent to participate. In the first round of recruitment only 2 preschools and 2 long day care services agreed to participate. For this reason, a second email was distributed to long day care services and preschools, after which an additional 3 participants were recruited. At the end of the second round of recruitment, all long day care services operating in the regional town had been invited to participate, however we were unsuccessful in recruiting a second long day care service in this location.

### Participants

One participant withdrew during week 6 of the project citing a reduction in their planning time restricting their ability to participate. Two more participants withdrew during weeks 11 and 12, both citing illness as the reason for withdrawal. Two of the three participants who withdrew from the project provided consent for the data already collected to continue to be used in this study. In addition to three withdrawals, one participant was promoted to a different role in the early learning setting and consequently became ineligible to continue as her role was primarily outside the classroom. Seven case studies at the start of the project were thus reduced to three at the end of the study (Table 1). Nonetheless, the reduced number of cases allows for theoretical replications across three of the four intended subgroups to be made (Yin, 2009).

The National Quality Standard Rating for each long day care service and preschool was retrieved from the national register (Australian Children’s Education & Care Quality Authority, 2020). Of the participants who withdrew from the study, two came from early childhood settings that were rated as ‘meeting’ and one rated as ‘working towards’ the national quality standard. Two of the participants who remained in the study were from settings holding an ‘exceeding’ rating and one was rated as ‘meeting’ the national quality standard. Additional data, including highest qualification, for the participants who remained in the study, hence forward identified as Case 1, 2 and 3 is included in Table 2.

### Implementation Resources

#### NT Preschool Science Games

The NT Preschool Science Games (Author, 2018) are one component of a nested suite of STEM resources rolled out across preschools and long day care services in the NT. The games provide a series of learning experiences that aim to promote children’s scientific thinking skills through encouraging active participation and back-and-forth conversations between children and adults. Learning objectives and word suggestions are provided with each game to facilitate intentional teaching and formative assessment to guide future science learning. In line with the EYLF (Department of Education Employment and Workplace Relations, 2009) and the Northern Territory Preschool Curriculum (Department of Education, 2016), for each game the use of a science process skill is highlighted along with why this learning is important for young children. In addition, links across STEM areas are made to support an integrated curriculum and further investigation and inquiry. Table 3 outlines the science process skills and content areas promoted in each game. Further, the games are freely available online (link withheld).

#### Professional Learning Seminar

A one-day professional learning seminar aimed to support teachers to embed the NT Preschool Science Games in their daily practice. The seminar was designed to establish a collaborative learning community and made use of a range of experiences aligned with classroom practice (Brenneman, Lange, & Nayfeld, 2018; van Driel & Berry, 2012). Participants were introduced to science process skills (as opposed to science concepts) in early childhood science education. Effective teaching strategies to support higher order thinking were discussed.

### Instruments

#### Classroom Observations

The Classroom Assessment Scoring System Pre-Kindergarten (CLASS) (Pianta et al., 2008) was used to measure the quality of teacher-child interactions at the classroom level. This instrument was selected as it supports the investigation of interactions that promote child learning within the micro-system (Bronfenbrenner, 1977). Further, the CLASS tool has been identified as a valid instrument for measuring classroom quality in research in Australia (Cloney et al., 2017; Tayler et al., 2013). The instrument comprises three domains (emotional support, classroom organization and instructional support) underpinned by ten dimensions. Five consecutive 20-minute observation and ten minute coding cycles were undertaken in line with the CLASS observation protocol (Pianta et al., 2008). Observations were conducted by the first author, a certified CLASS observer, and commenced at the start of the preschool day to avoid time-of-day bias (Thorpe et al., 2020). Consistent with the CLASS protocol, behavioral indicators and descriptions for low (1-2), medium (3-5) and high (6-7) levels of quality were used to assign a score on a 7-point scale for each quality dimension (Pianta et al., 2008). At the start of each cycle of observation, the learning domain (e.g. literacy, numeracy, science) and format of the learning environment (e.g. whole group, small group) were recorded.

#### Interview

A semi-structured interview protocol was designed to understand the participants’ lived experience of using the NT Preschool Science Games in their classrooms (see Appendix). Interviews explored teachers’ evolving teaching strategies as they became familiar with the NT Preschool Science Games. Couched in unambiguous language questions aimed to achieve a positive dynamic interaction between the researcher and participant (Kvale & Brinkmann, 2009). Pre-planned prompts were intended to use if it was necessary to clarify answers to facilitate later thematic coding (Kvale & Brinkmann, 2009). Initial questions addressed teachers’:

* use of the NT Preschool Science Games
* beliefs about supporting children’s scientific thinking in the context of an early childhood curriculum,
* the involvement of parents and the principal or service director in the implementation of the NT Preschool Science Games.

In addition, the teachers were provided feedback by the interviewer, who also conducted the observations, on differences observed in their pre- and post-implementation CLASS observations. Subsequently, they were to comment on what influenced their selection and use of teaching strategies. Interviews were of 45 minutes duration and conducted in a meeting room onsite at each service upon completion of the post-implementation CLASS observation.

### Procedure

The study was timed to coincide with the launch and distribution of the NT Preschool Science Games to preschools across the Northern Territory. Figure 1 provides a key overview of the sequencing of data collection and implementation activities. Our approach enables the analysis of teacher-child interactions as teachers become increasingly familiar with the NT Preschool Science Games over the course of the implementation period.

After negotiating a suitable day with classroom teachers to undertake an observation, room level interactional quality across one full morning program was assessed using the CLASS Pre-K (Pianta et al., 2008) in each participating preschool and long day care classroom. This determined initial ratings for classroom interactions in business-as-usual programs. Teachers undertook to deliver one typical science learning experience during the observation period. On the morning of the observation, a brief discussion was held with the teacher to determine their schedule for the morning program in order for the observer to ensure a CLASS observation cycle coincided with the science learning experience. Despite having agreed not to use the NT Preschool Science Games until after having attended the professional learning seminar, all three participants enacted one of the games from this resource during the pre-implementation CLASS observation visit. All participants confirmed this was their first use of the NT Preschool Science Games.

Following the pre-implementation CLASS observations, teachers were invited to attend a professional learning seminar to support their inclusion of the NT Preschool Science Games in their curriculum. At the conclusion of the professional learning seminar, teachers undertook to use the NT Preschool Science Games on a weekly basis from May through to September.

In mid-September, participants were contacted to arrange a suitable time for the post-implementation CLASS observation and interview. The same procedure for the pre-implementation CLASS observation was observed, with one minor change. A week prior to the post-implementation observations, participants were asked to choose a NT Preschool Science Game to enact with the children. At the conclusion of the CLASS observation, participants were provided with a break, following which the interview was conducted.

### Data Analysis

To interpret the impact of the Northern Territory Preschool Science Games on classroom quality, data from observations, interviews and the resource itself will be triangulated (Flick, 2019). Figure 2 demonstrates the analytic approach applied in this study. The content analysis illuminates the affordances of the NT Preschool Science Games by identifying prompts and opportunities for high quality instructional support interactions provided by the games; intra-case analysis of CLASS scores allows for differences in classroom quality during the preschool day to be examined. The thematic analysis of teacher interviews provides contextual information to inform the interpretation of the overall analysis of classroom quality within the three preschool programs. Each analysis links to the central theme of classroom quality and will be discussed in turn below.

First, a deductive content analysis was undertaken to identify the affordances of the NT Preschool Science Games (Finfgeld-Connett, 2014). The CLASS (Pianta et al., 2008) instructional support domain provided the core framework for coding the 16 games of the NT Preschool Science Games resource. The instructional support domain consists of three dimensions; concept development, quality of feedback and language modeling. Each of the dimensions is defined by indicators, of which there are various fine grained behavioral markers (Figure 3). These fine grained behavioral markers were used to code the NT Preschool Science Games. This allowed for subsequent analysis at the indicator and dimension level. An example of the application of the coding framework is demonstrated in Table 4.

In addition, a second coding framework entitled ‘Science Content, Skill and Planning’ was created. This second framework identifies information included in the NT Preschool Science Games that does not create opportunities for instructional support interactions per se, but does support the teaching and learning of science. The codes include ‘preparation for science learning’, ‘scientific content knowledge’ and ‘scientific process knowledge’ (Figure 3). All text in each of the 16 NT Preschool Science Games was coded using the coding framework.

Second, a thematic analysis of the interview data was conducted. For the purposes of this study, only the responses to questions regarding feedback on CLASS observations, participants perceived influences on, and their choices of, teaching strategies were analyzed. This thematic analysis allowed for identification of relationships between interview and observational data (Boyatzis, 1998). The inductive analysis began with an individual review of each case. Initial codes and memos were noted alongside the transcript. The initial codes were then reviewed across cases and adapted to ensure consistent application across cases. Six codes were thus identified and grouped into four themes. Illustrative quotes for each theme were selected for reporting. Finally, intra-case comparison of CLASS observation scores were conducted to identify trends that emerge in teacher-child interactions when the NT Preschool Science Games are used in a morning preschool program. Upon completion of the three analyses by the first author, all three authors met to discuss the data and results.

## Results

### Affordances of the NT Preschool Science Games

Interaction prompts that support concept development are the most frequently provided in the NT Preschool Science Games (221) followed by Science Content, Skills and Planning (139), and prompts for language modelling (127) and high quality feedback (83). This equates to an average of 13.81 prompts for concept development, 8.69 prompts for Science Content, Skills and Planning, 7.94 prompts for language modelling and 5.19 prompts for quality of feedback per game. Taking a closer look at the indicators, prompts for analysis and reasoning are most frequently provided in the NT Preschool Science Games (162) followed by scientific content knowledge (62). Figure 4 identifies the frequency of the top ten instructional support indicators and Science Content, Skill and Planning prompts provided in the NT Preschool Science Games. It is important to note that the games are intended to model pedagogical strategies that teachers may choose to adopt while teaching science, not to provide a definite list of things to do. Rather, the aim of the resource is to support transferrable teaching strategies that could be used in any of the games and in any teaching context outside of science.

### Teacher-child interactions: Domain level

Results of the CLASS observations for participants who remained in the study are presented as individual cases at pre- and post-implementation. Each case is a set of scores representing the observed quality for each domain during each observation cycle (Figures 5 to 10). These scores were obtained by averaging the dimension scores for each domain by observation cycle. A box that includes the cycle number identifies the cycles where a NT Preschool Science Game was enacted by the lead teacher. In each case, for the pre-implementation observation the teacher sought out the NT Preschool Science Games resource on their own accord. One of these games was implemented rather than a business as usual science experience, as was asked in the recruitment phase.

Intra-case comparisons demonstrate that each case maintained mid to high levels of emotional support and classroom organization across the pre- and post-implementation observations (Figures 5 & 6 for Case 1, Figures 7 & 8 for Case 2, Figures 9 & 10 for Case 3). In contrast, the instructional support scores show higher change between observation cycles within each case. Case 1 exhibited a low level of instructional support quality throughout the pre-implementation observation (Figure 5). This trend continued in the post-implementation observation, except for the cycle when the science game was enacted and instructional support quality rose to the high range (Figure 6). The change was less for Cases 2 and 3, where instructional support quality was rated low- to mid-range across pre- and post-observations, reaching a peak of mid- to high-range quality when the games were enacted (Figures 7 & 8 for Case 2 and Figures 9 & 10 for Case 3). These results warrant further analysis of instructional support scores at the dimension level in the next section.

Given the level of participant attrition in this project it was thus relevant to investigate CLASS scores, and in particular instructional support scores achieved in classrooms that remained in the study for the duration of the implementation phase and those that withdrew from the study (Table 5). Data for one participant who withdrew at 10 weeks has been omitted as they did not provide consent for collected data to continue to be used. It was identified that the average domain scores were lower for the participants who withdrew from the study compared with those who remained in the study (Table 5).

### Teacher-child interactions: Instructional support

As the earlier content analysis of the games identified a large number of affordances for instructional support prompts within the games, a fine-grained analysis of concept development, quality of feedback and language modelling was conducted to compare instructional support interactions between pre- and post-implementation. The average scores for the instructional support dimensions were calculated for the participants who remained in the study and are listed in Table 6. For each case, concept development scores were higher at post-implementation. Quality of feedback was higher at post-implementation than pre-implementation for Cases 1 and 3, whereas Case 2 scored higher on this dimension at pre-implementation than post-implementation. Across all cases, language modelling scores were lower at post-implementation.

Further, the instructional support dimension scores for each observation cycle at pre- and post-implementation are presented in Figures 11 to 16. For Case 1, at post-implementation concept development, quality of feedback and language modelling are all scored in the mid to high range when a NT Preschool Science Game is implemented (Figure 12). This is in contrast to four cycles of the broader early childhood program where all but one of these dimensions were scored in the low range.

At pre- and post-implementation, when enacting an NT Preschool Science Game, Case 2 scored in the mid to high range for all instructional support dimensions (Figures 13 & 14). The highest scores for concept development, quality of feedback and language modelling occurred in cycles when a NT Preschool Science Game was being enacted by the lead teacher. Similarly, across pre-and post-implementation observations for Case 3, highest dimension scores were observed during the enactment of an NT Preschool Science Game (Figures 15 & 16)

### Interviews

Interviews were conducted with the (three) remaining study participants. Interview data were analyzed thematically. Four themes emerged: NT Preschool Science Games supporting teaching practice, philosophy of teaching practice, further education and child focus guiding teaching practice. Illustrative examples of quotes related to each theme are provided in Table 7. However, only one participant spoke about the NT Preschool Science Games supporting teaching practice and further education. Two participants explicitly discussed their pre-school’s philosophy of teaching practice and all three referred to a child focus guiding their teaching practice.

## Discussion

The present study was designed to ascertain the affordances for instructional support interactions provided by the NT Preschool Science Games and to examine the differences in instructional quality when the games are enacted within broader early childhood programs. With respect to the first objective, it was identified that the NT Preschool Science Games most frequently offer prompts for analysis and reasoning, an indicator for concept development. Analysis and reasoning is facilitated by the NT Preschool Science Games through offering suggestions for open-ended questions and encouraging opportunities to problem solve, experiment and predict, compare and classify, and evaluate and summarise (Pianta et al., 2008). This indicates that the NT Preschool Science Games offer strategies for teachers to move away from the rote memorisation of facts and instead support children to think about the how and why of learning.

When comparing the quality interactions during the use of the NT Preschool Science Games and the broader early childhood education program, an increase in instructional support quality in the cycle in which a game is enacted was observed. In particular, there are gains in the dimension of concept development. These findings align with those of both Kook and Greenfield (2020) and Cabell and others (2013), suggesting the most effective instructional support interactions occur during science learning experiences, in this case the implementation of an NT Preschool Science Game. More specifically the current study identified an increase in concept development interactions during the context of science. The increase in quality while enacting an NT Preschool Science Game suggests that teachers may be translating the affordances of the games into practice. Alone, this teaching resource sits within the exosystem of a child’s ecological environment (Bronfenbrenner, 1977). Whilst it does not have a proximal influence on learning, teaching resources have a direct effect on a teacher’s practice and thus teacher-child interactions. The prompts provided in the games are an initiation point. In order to effect change within the microsystem, a teacher is required to take these prompts and opportunities for learning and transform them to enact high quality instructional interactions with the child. For example, the games offer suggestions for open-ended questions. These would assist a teacher to initiate an interaction with a child, setting up opportunities for back-and-forth conversation. This in turn creates opportunities for the provision of feedback. Here the NT Preschool Science Games are acting as a scaffold for the teachers to transform the prompts for high quality teacher-child interactions into practice within science education. Examples of open-ended questions in the games support teachers to initiate an interaction by inviting children to analyze and reason, to brainstorm and plan. The games encourage teachers to integrate new ideas with children’s previous knowledge, making connections between science explorations in the preschool classroom and the real world.

When observed changes in teaching strategies were discussed with teachers, one attributed this to using the NT Preschool Science Games as supporting her practice but all three suggested the change in their practice was due to influences unrelated to the games. Despite this, the highest level of instructional support quality and in particular concept development was observed when they were using this resource. Given that the participants identified the impacts of undergraduate study and adopting either an inquiry or Reggio Emilia influenced philosophy of teaching practice as key drivers facilitating the change in their teaching practice, consistent change across cycles of observations at post-implementation would be expected. This was not observed. Rather an increase in instructional quality was observed *only* in the cycle where teachers used the NT Preschool Science Games. In fact, each teacher rated in the high range for instructional support while enacting a game during the post-implementation observation (Figures 6, 8 and 10). This demonstrates that with some external guidance, these teachers have the skills to deliver high quality instructional support. Perhaps, teachers are yet to realize the potential of their current pedagogical abilities and require further understanding of how teaching resources such as the NT Preschool Science Games can enhance their teaching. Highlighting the affordances of the games for supporting high quality teaching may equip teachers to reflect on effective strategies they use in order to apply them purposefully across the broader program.

Surprisingly, in each case, language modelling scores were lower once teachers had become more familiar with the NT Preschool Science Games. Advanced language, open-ended questions and frequent conversation are three of the language modelling indicators among the top ten affordances of the games. The emphasis on language modelling within the games, however, was far outweighed by that of concept development. Perhaps as teachers became more familiar with the games, this shift was reflected in their emphasis on concept development. This warrants further research as it could have implications for the design of future resources.

In light of low levels of instructional support observed in Australian early childhood education and care settings (Tayler et al., 2013) and research suggesting teachers seldom purposefully engage in scientific thinking with children (Gelman & Brenneman, 2004; Nayfeld et al., 2011; Tu, 2006), the high level of attrition in this study was of interest. The participants who withdrew from this study had lower levels of classroom quality across all three domains than the participants who remained in the study. This was further supported by examining the national quality ratings which highlighted a similar trend. One possible explanation is that in services of higher quality there may be additional support for, or teachers are more receptive to, further professional learning and they continue to extend their practice. Those within lower rated services may have alternative priorities and the importance of science in early childhood may not yet be realized. The teaching focus in these services could be on traditional areas of learning that are more visible within the learning frameworks rather than science education which, outside of this resource provided by the NT DoE, is only implied. Further, consideration for reaching a threshold of domain general quality prior to focusing on additional learning areas such as science may be warranted in cases of low quality.

### Limitations

There was a mixed response to the invitation to participate in a research project focusing on science teaching and learning in early childhood. A high workload and a lack of interest in the project were predominant responses for not participating. This may be an indication that science is perceived as additional to ongoing teaching and learning as it is not explicitly discussed in the EYLF (Department of Education Employment and Workplace Relations, 2009). Here, the status of science education in early childhood curricula could be limiting the range of participants involved in the study.

Challenges were faced retaining participants due to illness, lack of planning time and movement into other jobs. The quality of services who withdrew from the study was lower than those that continued to participate. Therefore, the results of this study are limited to services rated as meeting or exceeding the National Quality Standard (Australian Children’s Education & Care Quality Authority, 2020). As a result, it was not possible to investigate the impact of the NT Preschool Science Games in services that were not yet meeting or working towards the National Quality Standard.

This study examined the NT Preschool Science Games as a collective suite of learning experiences. Each game was designed to explicitly promote children’s higher order thinking, encourage language and extend learning through back-and-forth exchanges between children and adults. This allowed for examination of classroom quality when any of the games were enacted. Further research examining the facilitating effect of each NT Preschool Science Game, coupled with multiple rounds of observations of teacher-child interaction during the use of specific games will provide further fine-grained detail on this resource. In addition, whilst the focus of this study was on the impact of the use of the NT Preschool Science Games on teacher-child interactional quality at classroom level, it would be of interest to systematically explore the impact of the games on child outcomes.

## Conclusion

This study adds to existing research on early childhood quality in Australia and extends this by focusing on the contribution of the purposeful inclusion of science learning experiences in informal early childhood curricula. First, we examined the affordances for instructional support interactions provided by the NT Preschool Science Games, identifying that prompts for analysis and reasoning occur most frequently within the resource. Second, we scrutinized the differences in classroom quality during the enactment of an NT Preschool Science Game compared with the broader business-as-usual early childhood program. Within cases, a higher level of instructional support was observed during the time teachers enacted an NT Preschool Science Game compared with their ongoing early childhood education program. Further analysis of the instructional support domain scores found a marked increase of concept development during these periods. This aligns with the key affordance of the games identified by this study. In general, therefore, it seems that the NT Preschool Science Games provide a supportive structure to enable teachers to transform pedagogical prompts into teaching practice. By enacting the NT Preschool Science Games, teachers draw a teaching resource situated within the child’s exosystem into a child’s microsystem, thus enhancing the classroom quality and potentially influencing child learning. Teachers in this study attributed changes in their teaching practice to factors that could impact classroom quality in a global manner. However, increases in instructional support quality were increases observed when the NT Preschool Science Games were used and not across the program. Whilst participants had attended a one-day professional learning day regarding the implementation of the games, we suggest that systematic professional learning should be provided to support teachers’ recognition and enactment of pedagogical strategies that increase the quality of instructional support within an informal curriculum.

This study describes one of the first attempts to examine the quality of teacher-child interactions specifically within the context of science education in Australia. Further work is needed to fully understand how the positive impacts on classroom quality achieved within the context of early childhood science education can be sustained across multiple observation cycles and learning areas. Optimal practice would be the enactment of pedagogical strategies that promote metacognitive development through problem solving, prediction, questioning, comparison and classification in the learning of every child.

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## Tables

Table 1

*Number of participants by service type and location at pre- and post-implementation*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Number of participants | | | |
|  | Capital City Preschool | Capital City Long Day Care | Regional Town  Preschool | Regional Town  Long Day Care |
| Pre-implementation | 2 | 2 | 2 | 1 |
| Post-implementation | 1 | 0 | 1 | 1 |

Table 2

*Case characteristics*

|  |  |  |  |
| --- | --- | --- | --- |
| Variables | Case 1 | Case 2 | Case 3 |
| Location | Regional Town | Capital City | Regional Town |
| Service Type | Long day care | Preschool | Preschool |
| NQS Rating | Exceeding | Exceeding | Meeting |
| Highest Qualification | Diploma | Bachelor’s degree | Bachelor’s degree |
| Number of children in classroom | 14-18 | 12 | 11-12 |

Table 3

*Northern Territory Preschool Science Games*

|  |  |  |
| --- | --- | --- |
| Title | Science Process Skill | Content Area |
| Growing alfalfa sprouts | Observing | Biological Science |
| Using our senses | Observing | Biological Science |
| Paper bag lungs | Observing | Biological Science |
| Watering plants | Observing | Environmental Science |
| Paint with water | Observing | Chemical Science |
| Insects and spiders | Classifying | Biological Science |
| What goes in compost? | Classifying | Environmental Science |
| Nature hunt | Classifying | Earth & Space Science |
| Rain gauge | Comparing | Earth & Space Science |
| Magnifying glasses | Comparing | Physical Science |
| How can we reuse this? | Communicating & Recording | Environmental Science |
| Making slime | Communicating & Recording | Chemical Science |
| Magnetic and non-magnetic | Communicating & Recording | Physical Science |
| Cloud diary | Predicting & Checking | Earth & Space Science |
| Sink and float | Predicting & Checking | Physical Science |
| Cars and ramps | Predicting & Checking | Physical Science |

Table 4

*Application of the instructional support coding framework to the NT Preschool Science Games*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| NT Preschool Science Game Prompt | Behavioral Marker | Indicator | Dimension | Domain |
| Go online with the children to explore how magnets are used in engineering and technology | Real-world applications | Connections to the real world | Concept Development | Instructional support |
| Ask the children to explain how they decided which group each object belonged with | Asks students to explain thinking | Promoting thought processes | Quality of Feedback | Instructional support |
| Use language to describe the objects as ‘magnetic’ and ‘non-magnetic’ | Variety of words | Advanced language | Language Modelling | Instructional support |

Table 5

*Average pre-implementation CLASS domain score*

|  |  |  |  |
| --- | --- | --- | --- |
| Domain | Participants who withdrew from the study | Participants who remained in the study | |
| Emotional Support | 5.38 | | 6.17 | |
| Classroom Organization | 4.04 | | 5.27 | |
| Instructional Support | 2.13 | | 3.47 | |

Table 6

*Average instructional support dimension scores at pre- and post-implementation per case*

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Dimension | Case 1 | |  | Case 2 | |  | Case 3 | |
|  | Pre-imp. | Post-imp. |  | Pre-imp. | Post-imp. |  | Pre-imp. | Post-imp. |
| Concept Development | 1.80 | 2.20 |  | 2.80 | 3.80 |  | 2.20 | 2.50 |
| Quality of Feedback | 2.40 | 2.80 |  | 5.40 | 5.00 |  | 4.00 | 4.50 |
| Language Modelling | 3.40 | 2.80 |  | 5.60 | 4.00 |  | 3.60 | 3.25 |
| **Instructional Support** | **2.53** | **2.60** |  | **4.60** | **4.27** |  | **3.27** | **3.42** |

Table 7

*Illustrative quotes for the four themes identified in post-implementation interviews*

|  |  |  |  |
| --- | --- | --- | --- |
| Theme | Case 1 | Case 2 | Case 3 |
| NT Preschool Science Games supporting teaching practice | “it basically tells you exactly what sort of things you should be saying, what sort of things you should be asking of the children…looking through that [the games] in depth helps” |  |  |
| Philosophy of teaching practice |  | [the change in practice is] “…all down to the journey that we are on with the Reggio Emilia approach”. | [the change in practice] “…is probably more because we have changed to the inquiry approach”  “… the same with inquiry, as they go up, it’s all about questions, it is a huge part of it like, so that’s probably where all the questioning comes from.” |
| Further education | “I am doing my bachelor at the moment as well so all of that sort of stuff goes into more depth than your diploma does so, you know [I am] probably just learning more about the questions and stuff you should be asking.” |  |  |
| Child focus guiding teaching practice | “it comes down to it is just knowing your kids” | “… letting the children know that their voices are important, that we hear them. We record them, we use them, and they inform our planning….” | “.. by encouraging them [the children] to question everything, then that’s where their independence comes from. That’s where their love of school comes from, because they’re like “Hey! Look at me, I figured that out myself!” So that’s why we do a lot of questioning.” |

## Figures

**Post-implementation**

September 2019

**Implementation**

May – September 2019

Professional Learning Seminar

NT Preschool Science Games

CLASS Observation

Interview

CLASS Observation

**Pre-implementation**

May 2019

#### Figure 1. Sequence of data collection and implementation activities

**Teacher-child**

**interactions**

Classroom Observations

*CLASS Analysis*

Interviews

*Thematic Analysis*

**Teacher perceptions**

NT Preschool Science Games

*Content Analysis*

**Affordances of the**

**NT Preschool Science Games**

Classroom Quality

*Figure 2.* Analytic approach

*Figure 3.* Coding framework for the NT Preschool Science Games

### *Figure 4.* The top 10 affordances of the NT Preschool Science Games

|  |  |
| --- | --- |
| Science  Game  Science  Game | Science  Game |
| *Figure 5.* Case 1 domain scores by cycle at pre-implementation | *Figure 6.* Case 1 domain scores by cycle at post-implementation |
| Science  Game  Science  Game  Science  Game | Science  Game |
| *Figure 7.* Case 2 domain scores by cycle at pre-implementation | *Figure 8.* Case 2 domain scores by cycle at post-implementation |
| Science  Game | Science  Game |
| *Figure 9.* Case 3 domain scores by cycle at pre-implementation | *Figure* *10.* Case 3 domain scores by cycle at post-implementation |

|  |  |
| --- | --- |
| Science  Game  Science  Game | Science  Game |
| *Figure 11.* Case 1 instructional support dimension scores by cycle at pre-implementation | *Figure 12.* Case 1 instructional support dimension scores by cycle at post-implementation |
| Science  Game  Science  Game  Science  Game | Science  Game |
| *Figure 13.* Case 2 instructional support dimension scores by cycle at pre-implementation | *Figure 14.* Case 2 instructional support dimension scores by cycle at post-implementation |
| Science  Game | Science  Game |
| *Figure 15.* Case 3 instructional support dimension scores by cycle at pre-implementation | *Figure 16.* Case 3 instructional support dimension scores by cycle at post-implementation |

## Appendix

*Semi-structured interview protocol*

|  |  |
| --- | --- |
| **Main Questions** | **Possible Follow-up Questions** |
| What was your first impression of the NT Preschool Science Games? | Did you see/use the games before you began participating in this research project? |
| How do you use the games in your curriculum? | Did you adjust the games to use them in your classroom? How?  Were there other adults/teaching assistants/parents etc involved with using the games with the children? Who? How did they use the games? |
| Do you believe that it is important for young children to learn science in early childhood? | Have you noticed any changes in your beliefs during your participation in this project? Why?  What has influenced your beliefs towards science in early childhood? |
| How would you describe your feeling towards teaching science in early childhood? | What do you think caused this feeling towards teaching science?  How do you feel about delivering a science learning experience before it starts? |
| Do you feel confident that you have enough knowledge required to teach science in early childhood? | When you feel like you don’t have the knowledge required, how do you respond? What do you do or don’t do?  What science knowledge do you think teachers need to teach science in early childhood? |
| I notice a change in ……. What do you think influenced this? | Can you tell me why you choose to use these strategies?  Are these strategies that you use in other areas of teaching eg literacy or mathematics?  How do you decide which teaching strategies to use when teaching science? |
| How did you use the SciDoc? | Were there any other people supporting you with your assessments? (taking notes, photos etc)  How does this form of assessment of learning compare with other child assessment that you do? |
| How do you see the SciDoc fitting into your business as usual assessment and planning of science learning outside of this research project? | How did you balance competing priorities during your planning time?  Would you continue to use the SciDoc now that this research project is ending? Could you tell me why/why not? |
| Did you use the early childhood science padlet during this project? If yes, how?  Did you look at any of the posts/prompts on the padlet? | Why do you think this happened?  What influenced you to use/not use it in this way?  If they have little to say: I noticed you posted ……. and then when… Can you tell me about what motivated you to post at this time?  What did you initially think of the idea of the early childhood science padlet? |
| Can you talk to me about the type of assistance/encouragement you received from your school/service and principal/director to support children’s science learning while you took part in this project? | How did this impact your participation in the project?  What type of support would you have liked?  What did you find most useful about this support from your principal/director/parents? |