School of Education

Fostering young children's creativity with STEM activities in online learning environments

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This is to confirm that the research conducted, and the writing of this thesis was under my principal supervision. Curtin University's rules and codes of practice governing Higher Degrees by Research were adhered to.

Professor Karen Murcia [redacted]

24th July 2024

July 2024

DECLARATION

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

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

The research presented and reported in this thesis was conducted in accordance with the National Health and Medical Research Council National Statement on Ethical Conduct in Human Research (2007) – updated March 2014. The proposed research study received human research ethics approval from Curtin University Human Research Ethics Committee (EC00262), Approval Number HRE2022-0342

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ABSTRACT

Nurturing creativity is considered one of the most important objectives in early childhood education, and the integration of science, technology, engineering and mathematics (STEM) is one area that can facilitate this. The purpose of this study is to identify quality pedagogical practices for fostering young children's creativity with STEM learning experiences in online learning environments. Previous research has highlighted the important role a child's environment plays in fostering their creativity, with the environment encompassing the physical space, people, and pedagogies. While there is a comprehensive understanding around nurturing creativity within a physical learning environment, less is known about creativity in an online context.

Prior to the COVID-19 pandemic, little research focused on young children's online learning experiences. During the pandemic, studies involving this age group focused primarily on experiences and perceptions of emergency remote learning, rather than intentional online learning resulting in the development of specific skills or knowledge. This gap creates an opportunity to explore the potential of online STEM learning experiences to meaningfully engage young children in creative thinking. This is of value given the prevalent issues for children accessing face-to-face learning opportunities in regional and remote areas.

Accordingly, this qualitative, multiple case study involved multimodal video analysis of regional Year 1 children as they engaged with STEM learning experiences delivered online synchronously by Scitech, Western Australia's leading science discovery centre. Findings from the data collection were used for narrative analysis to create rich, written descriptions of the children's experiences. To provide a wider perspective of their experiences, multiple semi-structured interviews with the children were conducted, as well as with their parents, classroom teacher, and Scitech facilitators. Mapping of the children's learning environments was conducted to strengthen insights into the impacts of their physical spaces. The data collected was analysed using the *A-E of Children's Creativity* framework (Murcia et al., 2020). Findings illustrate how intentional online learning experiences can engage children creatively, using hands-on learning activities, effective communication, and providing quiet time to focus. These findings inform recommendations for how future online learning environments can be established to offer the most opportunities for young children's creativity.

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DEFINING TERMS

Definitions of key terms used throughout this thesis:

Creativity: the ability to generate original ideas that are appropriate to the task at hand (Murcia et al., 2020, p. 1399).

Emergency remote teaching: a temporary shift of instructional delivery to an alternate delivery mode due to crisis circumstances. It involves the use of fully remote teaching solutions for instruction or education that would otherwise be delivered primarily face-to-face and that will return to that format once the crisis or emergency has abated (Barbour et al., 2020, p. 6).

Experiences: events or activities which contribute to children's sense of wellbeing, learning and development (Australian Government Department of Education, 2022b, p. 66).

Online learning: the delivery of education in which digital technology and the Internet are used to deliver instruction and to facilitate communication among participants (Saqlain et al., 2020, p. 39).

STEM: The approach to teaching STEM content of two or more STEM domains (science, technology, engineering, maths), bound by STEM practices within an authentic context for the purpose of connecting these subjects to enhance student learning (Kelley & Knowles, 2016, p. 3).

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COPYRIGHT STATEMENT

I have obtained permission from my co-authors to include an extended extract from our published work, *Fostering young children's creativity in online learning environments: A systematic literature review* (Maslin et al., 2023).

CHAPTER 1: INTRODUCTION TO THE STUDY

1.1 INTRODUCTION TO CHAPTER 1

Nurturing creativity is considered one of the most important objectives in early childhood education, and the integration of science, technology, engineering, and mathematics (STEM) is one area in which to facilitate this. The purpose of this study is to identify quality pedagogical practices for fostering young children's creativity with STEM experiences in online learning environments. This introduction chapter provides contextual information about the study, beginning with the researcher's personal motivation for the study. Following this, background information is presented along with the research problem and research questions. Then, an overview of Scitech's services and the research methodology are outlined. This is followed by benefits of the study and thesis structure. Each of these sections will be elaborated on in the subsequent thesis chapters.

1.2 PERSONAL MOTIVATION FOR THE STUDY

There are several reasons I felt compelled to engage in this research project. First, was my interest in STEM education. I have previously worked as a Digital Technologies teacher, as well as three years as a Pre-Primary to Year 6 STEM specialist teacher. During this time my favourite aspect was seeing children display creativity and innovation during design-based challenges. Engaging in this study was an opportunity for personal professional development, in which I learnt more about STEM education and quality practices for future modes of delivery. Second, was my personal experience living and teaching in regional Western Australia. I moved from Western Australia's capital city of Perth to Esperance, a small coastal town 700km south-east of Perth, in 2016. Over the years I have experienced first-hand the barriers of living so far from the city – from Internet connectivity issues, to limited access to educational services and professional development. I strongly believe no child or teacher should be disadvantaged because of where they live, and that technology offers opportunities to help close these gaps. This research project offered an opportunity to learn more about how technology could assist learning and teaching in this space. During the initial outbreak of the COVID-19 pandemic, and subsequent lockdowns, I offered free Zoom practice sessions for teachers in Australia and the

USA as they navigated this new platform. I also published *The Zooming Owl,* the first children's short story to address transitioning to online learning in an entertaining and age-appropriate way. This story was made freely available online as an eBook via Amazon. Through these experiences, I gained insight into the possibilities and challenges faced by educators when engaging in online learning for the first time.

Each of these experiences prepared me to undertake this study. I see the value in exploring the ways online delivery could help children in regional areas access meaningful and authentic learning opportunities. I am excited these opportunities have presented themselves in the form of Scitech's engaging and well-received STEM sessions and shows. Upon commencement of this study, background research into the areas of creativity, early years STEM education and online learning was undertaken to understand the key concepts underpinning the study.

1.3 BACKGROUND OF THE STUDY

Creativity is an essential competency that is prioritised in early childhood education settings. Through various approaches such as play-based learning and science inquiry, children can develop original or novel solutions to problems. One avenue that presents an effective opportunity for children to engage creatively, is that of STEM education. An integration of science, technologies, engineering, and mathematics, STEM education typically provides hands-on, design-based activities, and investigative tasks for children to engage with (Wan et al., 2021). A strong body of research has explored the components of a learning environment that make it conducive to fostering children's creativity, focusing on aspects such as the resources, communication, and socio-emotional climate (Cremin et al., 2013; Davies et al., 2013b; Murcia et al., 2020; Richardson & Mishra, 2018). Research into children in physical learning environments has also identified characteristics demonstrated when they are engaged creatively, namely showing agency, being curious, making connections, being daring, and experimenting (Craft et al., 2014; Cremin & Chappell, 2021; Glăveanu, 2018). Additionally, children are known to display incidental moments of creativity as they engage in daily activities (Beghetto, 2007; Kaufman & Beghetto, 2009).

However, this understanding of learning environments has been formed almost exclusively around school-based, physical learning environments. As such, there is little understanding of how children could engage creatively during STEM learning experiences that are delivered online. Online delivery of education has been offered worldwide for decades and is a growing field of research (Barbour et al., 2020). Yet it was the global surge in emergency remote learning during the COVID-19 pandemic, commencing in 2020, that catapulted online learning to the forefront of educators', researchers', caregivers', and children's minds. At its peak, more than 1.6 billion children and youth were affected by school closures, and of these, 463 million children were unable to access remote learning (UNICEF, 2022). As such, there is now more willingness to explore the ways online learning could help address learning divides for children who live in regional or remote areas.

In Western Australia, regional and metropolitan areas are outlined in the *Regional Development Commissions Act 1993.* Based on these areas, 449 of the 1,051 schools are located outside the Perth metropolitan region (Australian Schools Directory, 2019). As a result, there are many children living in regional and remote areas whose access to face-to-face education services are limited, and instead seek opportunities through online delivery. For this to successfully occur, learners require access to reliable Internet services (Park, 2017). There have been ongoing efforts at a national level to ensure people living in all regions of Australia are able to access stable Internet connections. One of the most highly publicised strategies has been the implementation of the National Broadband Network (NBN); however, even with this roll-out, there is still two-thirds of Australia's land area that suffer from lack of connectivity (Good Things Foundation, 2021). The impacts of this were particularly noticeable during COVID-19 emergency remote teaching, where Australian educators reported that unreliable Internet impacted children's learning and engagement (Fray et al., 2022; Page et al., 2021; Van Bergen & Daniel, 2022). Findings by Fray et al. (2022), in particular, acknowledged that educators in regional and remote areas of Australian faced additional burdens related to unreliable Internet access.

Aside from issues with connectivity, there is also a lack of understanding about effective pedagogical strategies that can foster young children's creativity in online learning environments (Maslin et al., 2023). The lack of research in this space presents an opportunity to explore how this approach could provide additional opportunities for children to engage with STEM education and develop transferable skills for learning, work and life.

1.4 RESEARCH PROBLEM

There has been an increased uptake of online education in recent years; however, little is known about effective pedagogical strategies for young children in this learning context, thereby presenting challenges for educators who seek effective strategies. While research during the COVID-19 pandemic explored the experiences and attitudes of young children during emergency remote learning, approaches for STEM education, and fostering key competencies, such as creativity, were overlooked. With the growing emphasis on accessibility, particularly for children in regional and remote areas, there is a need to explore methods for fostering these skills in online learning environments. The purpose of this study was to explore how young children in regional Western Australia were able to engage creatively in STEM learning experiences delivered online by Scitech.

1.5 RESEARCH QUESTIONS

Based on the research problem, the two research questions driving this study were:

1. How do environmental elements influence children's creativity during STEM online learning experiences?
2. In what ways do children demonstrate creativity while engaging in STEM online learning experiences?

1.6 OVERVIEW OF SCITECH

Scitech is Western Australia's leading science discovery centre. Located in West Perth, Scitech is a not-for-profit organisation supported by the Western Australian Government through the Department of Jobs, Tourism, Science and Innovation. Scitech was founded in 1988 and provides a range of education outreach services to the state, including: an interactive science discovery centre located in West Perth that provides exhibitions, science shows, and puppet shows; regional outreach via their

Statewide program; STEM workshops; professional development; as well as incursions and excursions.

Scitech states that their purpose is to, "inspire engagement by all Western Australians in science, technology, engineering and mathematics" (Scitech, n.d.-b). As such, they do not specifically align their services with the Australian curriculum. They are committed to engaging with every child and school across the state, and each year, their Statewide program sees Scitech facilitators travel to hundreds of schools to provide incursions to over 500,000 children. Through this program, Scitech is committed to visiting each West Australian primary school every three to five years (Scitech, n.d.-a).

It was this commitment to increasing engagement with regional children and schools that led to the positive collaborative relationship throughout this research project. Through their involvement in the study, Scitech were able to prepare and deliver an experimental version of their existing programs online to children, providing an opportunity to assess the feasibility of offering a service like this in the future. From Scitech's perspective, they hoped online delivery could become an additional service each year to regional schools, which would complement the Statewide visits occurring every three to five years. In doing this, Scitech could further fulfil its commitment of engaging all West Australians in science and technology.

1.7 OVERVIEW OF RESEARCH METHODOLOGY

A constructivist approach was chosen for this study, guided by an interpretive epistemology. Qualitative research methods were used - a common approach in education research. As the study was focused on Year 1 children based in regional Western Australia, a case study methodology was chosen with three children serving in each case.

The children participated in ten sessions delivered synchronously by Scitech, six school-based sessions via Microsoft Teams (https://teams.microsoft.com/v2/) and four home-based sessions via Zoom (https://www.zoom.com/). Each session was observed by the researcher who was present in the classroom or children's homes.

Scitech staff were responsible for designing the sessions, each of which were adapted from Scitech's existing programs, as well as shipping packs of materials to the classroom teacher and children.

Each session was video recorded for multimodal analysis, and the researcher also took photographs and field notes. Underpinning the analysis process was the *A-E of Children's Creativity* framework (Murcia et al., 2020). Findings from the recordings were used for narrative analysis to create rich, written descriptions of the children's experiences, specifically describing observations of their creativity and how it was fostered.

The children also participated individually in three semi-structured interviews with the researcher, two at school, and one at home. The interviews gave the children the opportunity to discuss their online learning experiences and respond to questions the researcher had based on analysis of the video data. To provide a broad range of perspectives into each case child's involvement of the sessions, their parents participated in a semi-structured interview, as did the two Scitech facilitators and the classroom teacher. As each of the children's caregivers identify as their biological parents, the term 'parents' is used throughout this thesis. Thematic analysis was conducted on the interview data, selected as an appropriate way to interpret individual's unique experiences.

Finally, diagrams were created by the researcher of each physical environment the children were in, namely the classroom and their home learning environments. This process was done to provide insight into the impact of the physical spaces on their creative thinking and learning experiences.

1.8 BENEFITS OF THE STUDY

This study offers several benefits to educators and children. The immediate benefit of this study was affording Scitech the opportunity to understand the impact of their programs in an online space. This allowed them to assess the feasibility of increasing the scope of their services to children living in regional and remote Western Australia. With the constructive feedback from this study, Scitech can look to offer increased contact with children living outside of metropolitan Perth by providing online workshops and/or shows. This would complement their Statewide program, without tripling their travel and staffing costs.

For the children participating in this study, they gained an additional opportunity to interact with Scitech and engage in STEM learning experiences. The documented experiences of the children in this study could ultimately lead to children across the state benefiting from additional services provided by Scitech, providing greater opportunities to develop their creativity. Further, these findings could support national and international STEM online educators to implement similar opportunities for online delivery, which may provide additional benefits for children's learning. Specifically, children in regional and remote areas often experience limited access to learning opportunities due to their distance, as well as the ongoing challenge of attracting and retaining qualified educators. Online delivery provides the potential for a wide range of learning opportunities from qualified educators. With this, comes a need for those educators to understand and apply principles of effective online pedagogy. One of the benefits of this study is the focus on developing guidelines for quality practice in this space.

Additionally, this study extends contemporary understanding of children's creativity. It offers a unique context for exploring how children demonstrate their creativity, adding to the international body of knowledge about physical learning environments as place of learning, to include online learning contexts. It explores the impact and nuances of children engaging creatively while online, extending our understanding beyond that of the COVID-19 pandemic's emergency remote learning experience.

Finally, the study offers specific insights into young children's engagement with online learning. While the growing field of online learning research has focused primarily on adult learners, this study offers a unique insight into the way young children can meaningfully learn through online delivery. This is a valuable contribution to the research field, offering guidelines for quality practice that can assist not just science discovery centres, but other distance and online education services.

1.9 THESIS STRUCTURE

Below is an outline of the thesis structure:

Chapter 1: Introduction - provides an overview of the purpose and context for the research project, as well as introduce the research questions and methodology.

Chapter 2: Review of Literature - presents a comprehensive exploration and synthesis of the current research within the areas of children's creativity, STEM education, online learning, and findings from the researcher and supervisors' systematic literature review into young children's creativity during online learning.

Chapter 3: Research Methods – details and justifies the research methodology, data collection techniques, and data analysis processes that were used for this research project. It also outlines ethical considerations, measures of research quality, and limitations of the adopted research method.

Chapter 4: Findings - presents the findings from the data collected during the study. This is presented firstly as a table summarising the experiences of each child during the Scitech sessions, then by diagrams of the children's physical learning environments. This is followed by a narrative analysis of the sessions that draws upon the multimodal analysis of video data, followed by a thematic analysis of the semi-structured interview data. Finally, a cross-case analysis of the three children is presented.

Chapter 5: Discussion – presents a discussion of the study's findings, drawing upon literature to highlight the ways the study's findings contribute to the existing body of research.

Chapter 6: Conclusion – presents a detailed summary of findings that answer the study's two research questions, as well as guidelines for quality practice when engaging children creatively online with STEM learning experiences. This is followed by the significance and limitations of the study, finishing with closing remarks.

1.10 CHAPTER SUMMARY

This chapter began by outlining background of the study, along with the researcher's motivations for the study. This was followed by an overview of Scitech and its involvement with the research project, as well as the study's research questions and methodology. Finally, benefits of the study were outlined, and the structure of the thesis was presented.

The study has addressed the way educators can foster children's creativity with STEM activities in online learning environments. The research involved three case study children living in regional Western Australia, who participated in ten STEM sessions delivered synchronously online by Scitech. By observing the children's involvement in the sessions combined with the interview data and environment mapping, this study sought to identify ways children demonstrate creativity online, as well as quality practice for fostering their creativity. Ultimately, this has helped formulate a series of recommendations applicable to contexts in which educators are providing online STEM learning experiences to children. This research is timely and has the potential to inform quality practice for future online learning experiences for children. The next chapter will provide a comprehensive review of the literature published in the areas of children's creativity, STEM education, online learning, and digital divide.

CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION TO CHAPTER 2

Chapter 1 introduced and provided context for the study, including background information, and the driving research questions. This chapter provides a review of the literature relating to the areas incorporated in the study. The review begins by defining *creativity* and its place in education, before outlining guiding creativity frameworks for educators and researchers. Specifically, the *A-E of Children's Creativity* framework (Murcia et al., 2020) is explained in detail, as this was used as the lens of analysis for this study. Following this, the impact of the physical learning environment on children's creativity, both in school and home settings are explored. Then, the topic of STEM is introduced in the context of early years education. This includes the evidence for effective teaching strategies for STEM learning experiences. Online learning is discussed, including its benefits, challenges, and the known pedagogies for teaching online. Finally, a review into what is known about young children's creativity in online learning environments is presented.

The purpose of this chapter is to synthesise current knowledge around creativity, STEM, and online learning in an early years' context. This helps identify gaps in the existing body of research, providing the foundation from which this study begins and focuses on. This research gap is represented in Figure 2.1.

Figure 2.1

Identifying the gap in research that guides this research project

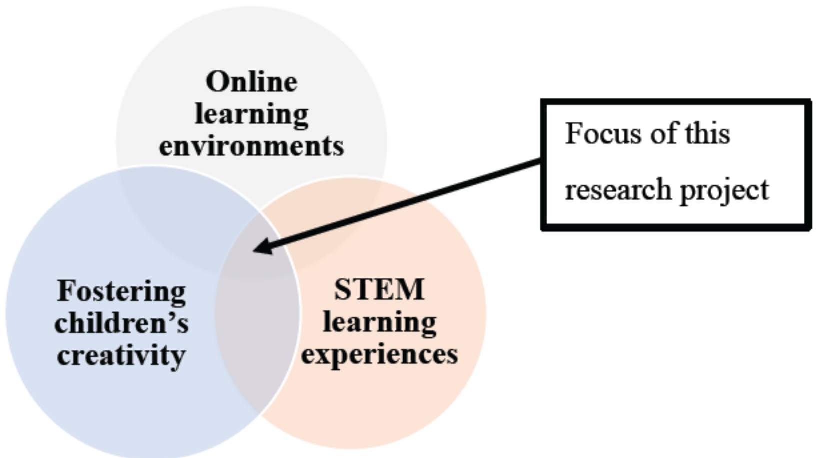


Figure 2.1 represents how established research fields exist for the areas of online learning environments, STEM learning experiences in a physical context, and children's creativity. It points, however, to a gap where these three fields intersect. There is currently limited understanding of how children's creativity can be fostered through STEM in online learning environments (Maslin et al., 2023).

2.2 CREATIVITY IN EDUCATION

The following section explores the role of creativity in education, specifically the definition of creativity; creativity in education policies; and creativity frameworks that are used in education.

2.2.1 Defining creativity

While the history of creativity can be traced back thousands of years (Glăveanu & Kaufman, 2019; Runco & Albert, 2010), it is widely accepted that modern creativity research was marked by Guildford's 1950 seminal presidential address to the American Psychological Association. In this, he advocated for a focus on creativity of the 'every man' (Glăveanu & Kaufman, 2019). Since then, creativity has become a topic in educational research (Hernández-Torrano & Ibrayeva, 2020; Kupers et al., 2019) and is widely regarded as a key competency for learners (Donovan et al., 2014; Rotherham & Willingham, 2010). Further, educational researchers support the notion that creativity is something that can be fostered in most children, not just a small number of gifted learners (Sheffield, 2017). Despite acknowledging its importance, creativity itself remains an elusive and complex concept with no universally accepted definition (Conradty & Bogner, 2018; Kupers et al., 2019). There is, however, general consensus that any definition of creativity will incorporate the components of originality and usefulness (Barron, 1955). Here, the component of *originality* refers to the expectation that an idea must be original, novel, infrequent or unique. Meanwhile, *useful* requires that the idea or product is of value to a group or culture. It should be noted that these components refer only to *creative products* as opposed to the creative process (Runco & Jaeger, 2012). For the purposes of this thesis, the following definition by Murcia et al. (2020) will be adhered to, "[creativity is] the ability to generate original ideas that are appropriate to the task at hand" (p. 1399). This definition was published by the authors of the *A-E* *of Children's Creativity* framework, which serves as the guiding tool of analysis for this study, reinforcing its relevance in the context of this research.

2.2.2 Creativity in education policies

Creativity has been identified as a key educational goal and has been incorporated into both Australian and international education policies and guidelines (Council of the European Union, 2018; Department for Business and Trade, 2018; Department of Education Skills and Employment, 2019; OECD, 2018; Richardson & Mishra, 2018; US Department of Education, 2024). For instance, within an international context, the Council of the European Union (2018) recommended learners of all ages develop key competencies which include skills such as creativity, problem-solving, and resilience. Similarly, the World Economic Forum has stated that children need to be creative thinkers, ready to adapt to new jobs that do not yet exist (World Economic Forum, 2016, 2018) and as such, education systems have attempted to implement strategies that foster this skill.

Within an Australian context, creativity is incorporated into *The Alice Springs (Mparntwe) Education Declaration,* where Goal 2 states that, "all young Australians become confident and creative individuals, successful lifelong learners, and active and informed members of the community" (Department of Education Skills and Employment, 2019, p. 6). Creativity is also included in the *Australian Early Years Learning Framework version 2* (Australian Government Department of Education, 2022a). While promoting children's creativity is mentioned throughout the framework, explicit mention is made in Outcome 4, "children develop a growth mindset and learning dispositions such as curiosity, cooperation, confidence, creativity, commitment, enthusiasm, persistence, imagination, and reflexivity" (p. 50). Again, creativity is explicitly referred to in the Australian Curriculum, embedded in the Critical and Creative Thinking general capability, which is required to be integrated across Foundation to Year 10 learning areas (ACARA, n.d.-b). Specifically, this capability outlines how "creative thinking involves students learning to generate and apply new ideas and see existing situations in new ways. They identify alternative explanations and possibilities, and create new links to generate successful outcomes" (ACARA, 2022). The inclusion of creativity within these guiding policies highlights the value which has been placed on fostering this skill in young learners.

2.2.3 Creativity frameworks

Two prominent frameworks have guided understanding of, and research into, creativity. These two frameworks, the *Four C Model* and the *Four Ps of Creativity* are outlined below.

The *Four C Model* identifies four constructs that differentiate between levels of creative magnitude (Kaufman & Beghetto, 2009). Firstly, the Big-C level describes eminent creativity from ground-breaking individuals such as artists, scientists, and world leaders; Pro-C creativity identifies successful people in their field who have not reached the prominence of Big-C creativity; little-c encompasses the less prominent acts of everyday creativity; and mini-c addresses new and personally meaningful interpretations, ideas and insights (Kaufman & Beghetto, 2009; Kaufman et al., 2022; Yu et al., 2021). The *Four C Model* frames creativity as a progression, in which individuals can continually develop their creativity, thus making it a valuable reference point for both researchers and educators. Additionally, the framework acknowledges *creative moments* that are novel to the child, even if they are not unique in a broader context. As such, it provides space for children's creativity to be acknowledged rather than overlooked. From this, educators can identify ways to further nurture this creativity, assisting children's development from one level to the next (Beghetto & Kaufman, 2014).

Underpinning decades of research is the *Four Ps of Creativity* (Rhodes, 1961), which classifies different approaches to creativity based on the level of the person, the product, the process, and the press. This model views the person as the central component of the creative product; the process is the procedure a person undertakes to create the product; the product is created by the person as a result of the creative process; and the press represents the person's working environment. The *Four Ps of Creativity* has been applied and adapted by researchers to help them classify creativity in various environments (Glăveanu, 2013; Murcia et al., 2020; Richardson & Mishra, 2018). One example in which the *Four Ps of Creativity* model has been adapted, is through the *A-E of Children's Creativity* framework. This framework has been selected as a lens for the data analysis in this study and is detailed in the next section.

2.3 *THE A-E OF CHILDREN'S CREATIVITY* FRAMEWORK

Drawing upon the *Four Ps of Creativity* (Rhodes, 1961), the *A-E of Children's Creativity* framework developed by Murcia et al. (2020) provides a field of reference for analysing creativity in the context of children and digital technologies (Fielding & Murcia, 2022). The framework outlines the role of the person, the product, and the process similar to the original approach, with a key distinction being the changing of *press* to *place* to better reflect an educational context. A full version of the framework is presented in Figure 2.2 which elaborates on the criteria for creative moments, the perspectives on who does the original thinking, the three elements of an enabling environment, as well as detailing the characteristics of the five creative processes.

Figure 2.2

A-E of Children's Creativity Framework

PRODUCT: Criteria for creative outcomes	
Original	Fit-for-purpose

PERSON: Perspectives on who does the original thinking		
Child engaged by educator's creativity	Child's creative doing	Child's creative thinking

PLACE: Elements of an enabling environment		
Resources	***Communication***	***Socio-Emotional Climate***
• Intentional provocations • Stimulating materials • Adequate materials for everyone • Time for creative exploration	• Intentional learning conversations • Hearing and valuing children's ideas • Open inquiry questioning • Facilitating dialogic conversations	• Stress and pressure free environment • Non-prescriptive • Non-judgemental • Allowed to make mistakes

PROCESS: Characteristics of children's creative thinking				
Agency	***Being Curious***	***Connecting***	***Daring***	***Experimenting***
• Displaying self-determination • Finding relevance and personal meaning • Having a purpose • Acting with autonomy • Demonstrating personal choice and freedom • Choosing to adjust and be agile	• Questioning • Wondering • Imagining • Exploring • Discovering • Engaging in 'what if' thinking	• Making connections • Seeing patterns in ideas • Reflecting on what is and what could be • Sharing with others • Combining ideas to form something new • Seeing different points of view	• Willing to be different • Persisting when things get difficult • Learning from failure (resilience) • Tolerating uncertainty • Challenging assumptions • Putting ideas into action	• Trying out new ideas • Playing with possibilities Investigating • Tinkering and adapting ideas • Using materials differently • Solving problems

Figure 2.2 illustrates the level of product, person, place, and process. Specifically, within the product level, products of creativity are identified as either "physical artefacts (e.g., a picture) or an abstract product (e.g., an idea)" (Murcia et al., 2020, p. 1400). The novelty of this product can be at an individual level, similar to that of little-c or mini-c creativity (Kaufman & Beghetto, 2009). While the product is often the main focus in the creative process, it has been noted that overemphasising the product can be problematic, as it fails to acknowledge creative potential and children's personal efforts (Beghetto & Kaufman, 2007; Long et al., 2022; Runco, 2005). A benefit of this framework is its inclusion of not just the creative product, but also three other components of creativity. Within the person level, three perspectives are described regarding the child's role in the creative activity: the child is engaged by the creativity of the educator; the child is involved in creative doing by following the educator's example or predetermined sequence of steps, and the child is the initiator of the creative ideas (Lucas & Spencer, 2017; McGregor & Frodsham, 2019; NACCCE, 1999). The place level and process level correspond with pedagogies for establishing a creative learning environment, which are outlined and analysed below.

2.3.1 Place

The learning environment is one of the most important factors in fostering children's creativity (Beghetto & Kaufman, 2014; Richardson & Mishra, 2018). The environment specifically refers to the set-up and design of the physical space, the relationship with other people in the space, and the availability of resources and support (Beghetto & Kaufman, 2014). Although research into creativity is increasing, the focus on the impact of learning environments on creativity has not risen with it (Richardson & Mishra, 2018). This is evidenced by Henriksen et al. (2015) who reviewed creativity instruments and found that only 3% of instruments measured the environmental support of creativity. Additionally, less than one-fifth of the total measures reviewed by the researchers were developed for children in K-12, further highlighting the gap in our understanding of creative learning environments in the early years. It has been asserted that there is a need to further assess how learning environments can assist educators in supporting the creativity of learners (Lee & Lee, 2023; Richardson & Mishra, 2018). Within the place level of the *A-E of Children's Creativity* framework, the elements of an enabling creative learning environment are organised under three categories: resources; communication; and socio-emotional climate.

Resources incorporates intentional provocations, enough stimulating materials for everyone, and time for creative exploration. An environment rich in materials, toys, and equipment has been found to positively impact children's creativity (Addison et al., 2010; Bancroft et al., 2008; Corlu et al., 2014; Gandini, 2005; Gkolia et al., 2009). Specifically, Bancroft et al. (2008) emphasised the need for lots of light, formless materials which can take on any shape, pointing to materials such as clay, modelling foam, wire, cellophane, and tissue paper. Further, it has been asserted that educators need to give children time and space by standing back during creative activities so that children have a chance to explore independently (Craft et al., 2012; Cremin et al., 2006; Cremin & Chappell, 2021; Murcia & Oblak, 2022). Similarly, Davies et al. (2013b) found through their literature review in school-aged learners that exciting activities, realistic tasks, and playful approaches that allowed time for children to have ownership of their learning contributed significantly to their creativity. Regarding intentional provocations, Murcia and Oblak (2022) found through their action research study with 3- and 4-year-old children that intentionality and scaffolding by the educator during early years learning can support their creativity. The existing research indicates the balance that educators need to make between providing support and space for children when engaging in creative tasks.

While the physical set-up of the environment is not explicitly mentioned in the *A-E of Children's Creativity* framework, numerous studies assert adequate space within a classroom should be used flexibly to promote creativity (Addison et al., 2010; Bancroft et al., 2008; Davies et al., 2013b; Jeffrey, 2006), and that there should be a general sense of openness and spaciousness (Bancroft et al., 2008), removing furniture to give children space to move around and make use of different areas (Gandini, 2005), and display works in progress (Addison et al., 2010). Beyond spaciousness, studies in Reggio Emilia schools by Vecchi (2010) demonstrated the importance of sensory qualities such as light, colour, sound, and providing spaces that allow for quietly working in groups.

Communication incorporates intentional learning conversations, hearing and valuing children's ideas, open inquiry questioning, and facilitating dialogic conversations. Educators play a pivotal role in fostering children's creativity, such as when they engage in conversations, and encourage children to actively participate and collaborate (Beghetto & Kaufman, 2014; Cremin et al., 2018; Marcos et al., 2020; Richardson & Mishra, 2018). Likewise, (Davies et al., 2013b) found that mutually respectful relationships built on trust between learners and educators, as well as collaborative activities, help support creativity.

There are many ways educators can facilitate communication to foster a positive relationship and stimulate creative thinking. For instance, questioning is regarded as an effective technique in encouraging creative thinking and problem-solving skills (Craft, 2007; Cremin et al., 2018). When students ask questions, they are engaging in higher order thinking, establishing relationships between new ideas and prior knowledge, and constructing meanings (Carli et al., 2022; Cremin et al., 2018; Thompson, 2017). The importance of questioning aligns with broader early years pedagogies, which advocate the importance of responsiveness to children. For example, in the *Early Years Learning Framework version 2,* responsiveness to children is explained in part as, "educators are attuned to, and actively listen to, children so they can respond in ways that build relationships and support children's learning, development and wellbeing" (Australian Government Department of Education, 2022a, p. 21). Beyond verbal communication such as questioning, silence has also been identified as a form of communication. This has been observed by Ollin (2008), however it is not accounted for in the *A-E of Children's Creativity* framework (Tippett & Yanez Gonzalez, 2022).

The *socio-emotional climate* involves creating an environment that is free from stress and pressure, non-prescriptive, non-judgemental, and supportive of children making mistakes. Reyes et al. (2012) note how upper primary classrooms, in which a positive emotional climate is promoted, are more likely to have learners who are engaged, enthusiastic, and academically successful. Classroom emotional climate can also influence children's motivation to engage in learning experiences (Urdan & Schoenfelder, 2006). It has been advocated that educators act as a guide rather than an instructor when children are engaging in creative tasks (Cress & Holm, 2016;

Richardson & Mishra, 2018; Woollard & Pritchard, 2010). The findings of Davies et al. (2013b) support this, encouraging a balance between structure and freedom so learners feel supported while engaged in creative thinking and risk-taking. This aligns with the notion of standing back and providing scaffolding outlined earlier in this section, speaking to the interconnectivity of the elements within the creative learning environment.

2.3.2 Process

Within the process level, five processes of children's creative thinking are presented: agency; being curious; connecting; daring; and experimenting. *Agency* has been identified in educational research as essential to the development of children's creative thinking (Cremin & Chappell, 2021; Cremin et al., 2018; Davies et al., 2013b; Tippett & Yanez Gonzalez, 2022). As asserted by Davies et al. (2013b), when children "are given some control over their learning and supported to take risks with the right balance of structure and freedom, their creativity is enhanced" (p. 85). This process further strengthens the elements of the environment, by providing children with a positive socio-emotional environment in which they feel supported while engaging in exploration and risk-taking.

It is widely accepted that children are innately *curious* (Banko, 2013; Cremin et al., 2018; Lange et al., 2019; Robinson & Lee, 2011; Tippett & Yanez Gonzalez, 2022). The process of being curious involves children questioning, imagining, discovering, and engaging in 'What if' thinking. This approach to thinking is closely aligned with the notion of *Possibility Thinking* (Craft, 2007) which involves a shift from asking 'What is this and what does it do?' to 'What can I do with this?' (Chappell et al., 2008, p. 267). Possibility Thinking is important for little-c creativity, providing a means by which questions are posed or problems identified (Craft, 2007), for example a five-year-old questioning how to make the right colour of paint (Chappell et al., 2008).

Making connections can occur through various activities, including play (Russ & Doernberg, 2019), personal connections to the topic (Harris & De Bruin, 2018), and to their own lives (Serebrin & Wigglesworth, 2014). This process also emphasises the importance of collaboration, by sharing ideas with others and seeing different points of view (Beghetto, 2019; Davies et al., 2013b).

Daring involves the willingness to be different, persist when challenges are difficult, and to be resilient. In the context of creativity, Lucas and Venckutė (2020) state, "tolerance for uncertainty, risk, and ambiguity…facilitate[s] higher learning, long-term employability, and upward social mobility" (p. 2). Research has demonstrated how age-appropriate STEM activities can assist with children's daring and resilience. For instance, in a study by Strawhecker et al. (2023), families with children aged 3- to 4-year-old were provided with packs of STEM materials to use at home to complete STEM tasks, such as building ramps. Caregivers commented that they were surprised by the perseverance their children demonstrated during these STEM tasks, noting they actively engaged in critical thinking, creating, evaluating, and redesigning.

Finally, the process of *experimenting* encompasses characteristics such as investigating, tinkering, and solving problems. It is widely accepted that engaging in these processes are beneficial for children's creativity (Chesky & Wells, 2017; Cooper, 2018; Cremin et al., 2018; Joubert, 2022; Smith & Smith, 2016; Thompson, 2017). For instance, Cooper (2018) states, "we learn to be creative by experimenting" (p. 645) while Thompson (2017) explains how the thinking of learners in primary and secondary classrooms becomes more independent when they engage in problem-finding and problem-solving. This links to the first characteristic of agency, reinforcing the framework's interconnectedness (Joubert, 2022). Additionally, the practice of predicting is referred to alongside that of experimenting for Foundation to Year 10 learners within the Australian Curriculum (ACARA, n.d.-a). This highlights the value placed on this skill; however, Falloon (2016) suggests that too much time spent on predicting could hold 5- and 6-year-old children back from overall progress, and needs to be balanced with risk-taking. Predicting is not specifically mentioned within the *A-E of Children's Creativity* framework, although wondering, questioning, engaging in 'what if' thinking, and investigating are related characteristics that are listed as part of the creative thinking process.

2.3.3 Demonstrations of creativity

Researchers have observed the ways in which children demonstrate creativity during face-to-face STEM activities by using the *A-E of Children's Creativity* framework as a lens of analysis (Murcia & Oblak, 2022; Murcia et al., 2020; Tippett & Yanez Gonzalez, 2022). Initially, Murcia et al. (2020) collaborated with educators from an Australian university's early years centre to observe children aged 3 and 4-years-old as they used BeeBots and iPads. They analysed episodes through the lens of the *A-E of Children's Creativity* framework, finding that children demonstrated the five processes at different activity stages. Specifically, they noted that agency and experimenting were most frequently observed.

Further, Tippett and Yanez Gonzalez (2022) examined children aged 18 months to 5-year-olds in a Canadian early childhood centre. They observed the young learners as they participated in daily activities, analysing episodes in which children engaged in STEM activities for evidence of creativity. Such activities included experimenting with wheelbarrows, ramps, and slides. The researchers found that children demonstrated all five processes during the episodes indicating the potential of physical STEM activities to offer creative opportunities.

Finally, Murcia and Oblak (2022) conducted action research in a Western Australian early years centre where they observed children's self-instigated constructions, before the children were presented with a specific design challenge. They observed processes of children's creativity during these observations, such as being curious, connecting, and experimenting. When the educator intentionally introduced the design process and inquiry questioning strategy, the children were engaged for longer periods of time and demonstrated a greater range of creative processes. This aligns with the use of demonstrations in teaching science, which have been shown to motivate learners by increasing interest and engagement (Treagust, 2013).

These three research projects utilising the *A-E of Children's Creativity* framework indicate that the framework is an effective lens through which to analyse children's demonstrations of creativity. They also contribute to the body of knowledge around children's creativity, and the positive learning experiences that come from engaging in STEM activities. However, the framework does not reference *focus*, a process which has been identified in other research relating to children's creativity (Tippett & Yanez Gonzalez, 2022).

2.3.4 Focus

The notion of focus has been explored in relation to creativity within concepts such as flow, engagement, and attention. Regarding *flow*, Tippett and Yanez Gonzalez (2022) found the *A-E of Children's Creativity* framework to be "appropriate for analysing episodes of creativity within young children's STEM learning experiences" (p. 146). However, they stated that missing from the framework was 'flow,' described as the state of being fully focused and immersed in the creative process (Nakamura & Csikszentmihalyi, 2002). Although missing from the framework, they noted it was not missing from their observations. While *attention* and *focus* are not explicitly included in the *A-E of Children's Creativity* framework, academics have pointed to the connection between children's attention and engagement and its links to creativity (Cremin et al., 2018; Glauert & Stylianidou, 2022; Martindale, 1999; Steele et al., 2017). Cremin et al. (2018) recognised that learners aged 3 to 8-years-old can experience *flow* while engaging in creative activities, and that this *flow* is sustained when learners are given agency over the activity. It has also been argued by Craft (2003b) that 'What if' thinking is often experienced unconsciously in the flow of engagement. These observations point to the way flow can be interconnected with the creative processes of agency and being curious. Further, additional time and attention can contribute to more detailed STEM solutions (Cremin et al., 2006), while eye gaze is often used as a measure of visual and auditory attention, even with kindergarten children (Fisher et al., 2014). Researchers have also noted that children may express their creative thinking and ideas through non-verbal forms of communication such as gestures (Goldin-Meadow, 2009), as well as drawings or actions (Glauert et al., 2013). Across these fields of research there appears to be an understanding of the importance of *focus* in children's creative thinking; however, there is a noticeable gap in incorporating focus explicitly within creativity frameworks and studies.

2.4 STEM AND CREATIVITY

The following section explores the intersection of STEM and creativity in an early years context. This includes outlining STEM pedagogies in the classroom; the creative experiences of doing STEM at home; and the creative outcomes of engaging in online STEM and theatre performances.

2.4.1 Understanding STEM in the context of creativity

STEM is an acronym representing the four disciplines of science, technology, engineering, and mathematics. First introduced in the late 1990s by the National Science Foundation in America (Blackley & Howell, 2015), it was hoped that STEM would lead to the development of increased skills within these areas, resulting in more people qualified to fill job gaps in STEM-related industries (Office of the Chief Scientist, 2013). Further to the economic and political reasons for STEM, it has been found that these learning experiences offer the potential to increase children's motivation, interest, and engagement at school (De Loof et al., 2021; Nadelson & Seifert, 2017). As such, countries around the world have invested in STEM education. For instance, in America, the U.S. Department of Education invested 279 million dollars to further STEM and computer science education (Wan et al., 2021). In Australia, the federal government has consistently invested in STEM education in recent years (Australian Government, 2024; Department of Education, 2018; Science & Technology Australia, 2021). Similarly, policy advisors in the UK and Hong Kong made commitments to strengthen STEM education in their schools (Department for Education, 2020; Education Bureau, 2022).

Despite the broad consensus to invest, there exists a range of perspectives around how to define and implement STEM education into schools (Bybee, 2013; Pitt, 2009; Rasul et al., 2018). However, it has become widely accepted that STEM learning refers to an *integrated* approach, with real-world application that has a focus on transferable skills and competencies (Aguilera & Ortiz-Revilla, 2021; Blackley et al., 2018; Fairhurst et al., 2023). One definition that epitomises this generally-held view, and as such is accepted for the purposes of this thesis, comes from Kelley and Knowles (2016):

> The approach to teaching STEM content of two or more STEM domains, bound by STEM practices within an authentic context for the purpose of connecting these subjects to enhance student learning (p. 3).

STEM learning experiences are regarded as opportunities for fostering children's creative thinking (Cremin et al., 2018; Tippett & Yanez Gonzalez, 2022; Wan et al., 2021). Specifically, it has been identified that STEM activities provide opportunities for children to apply their knowledge from different perspectives, solve problems, and collaborate with others, which in turn fosters their creativity (Bagiati & Evangelou, 2015; Stone-MacDonald et al., 2015). This section explores STEM in an early year's context, STEM teaching strategies, home-based STEM learning experiences, and STEM online educators and theatres.

2.4.2 STEM in an early years context

Introducing children to STEM learning experiences from a young age can positively impact their academic futures. Early years learning has a significant and long-lasting effect on children's cognitive and academic achievements (Campbell et al., 2001; Wan et al., 2021). Specifically, researchers have identified the 'golden age' of creativity is in preschool years (Alfonso-Benlliure et al., 2013; Üret & Ceylan, 2021; Wan et al., 2021), and that their engagement in STEM education at this time is positive, and the effect permanent (Üret & Ceylan, 2021). As a result, young children are equipped with the knowledge and skills needed for more complex STEM concepts in later years (Geary et al., 2013; Lind, 1998; Locuniak & Jordan, 2008). The positive impact of STEM activities on fostering young children's creativity was a contributing factor for choosing Scitech's STEM activities as the context for this study.

It has been noted how young children are innately curious, creative, and collaborative; all characteristics needed to participate in integrated STEM education (Banko, 2013; Cremin et al., 2018). They also have a natural disposition to analyse, hypothesise, and predict, as well as work with materials, experiment, and problem-solve (DeJarnette, 2018; Katz, 2010). They naturally engage in engineering practices such as creating and manipulating objects (English, 2018; Lippard et al., 2019; Strawhecker et al., 2023), and are persistent and determined when building designs (Van Meeteren, 2015). This aligns with the nature of STEM learning, which emphasises problem-solving, reasoning, and critical thinking (Simoncini & Lasen, 2018). Yet, children are known to not always solve problems or complete tasks in the expected manner (Bers et al., 2019), which aligns with the novelty aspect of creativity. Additional elements of STEM education in an early years context include posing a problem or challenge to be solved, with a focus on processes - critical thinking, experimentation, proof, and reasoning - and providing a meaningful experience where children make connections between the STEM content and the world around them (Linder et al., 2016).

2.4.3 STEM pedagogies

The following section explores STEM pedagogies, including constructivism; activity structure; agency and intentionality; physical resources; and constraints.

2.4.3.1 Constructivism

A key principle underpinning early childhood education is that of *constructivism* (Dietze, 2006). It is generally understood that children are active participants in the construction of their own knowledge (Lippard et al., 2017; Morrison, 2018; Piaget & Cook, 1952; Vygotsky & Cole, 1978). For instance, Vygotsky and Cole (1978) presented ideas about the importance of play, active learning, socially mediated knowledge, and the role of a more knowledgeable other. This has had a significant influence in the field of early childhood education (Tippett & Yanez Gonzalez, 2022; Van Hoorn, 2014). Additionally, Lippard et al. (2017) found, through their review of published engineering research involving 3- to 5-year-olds, that their engineering thinking was promoted when informed by their educator's knowledge of constructivist learning theory.

2.4.3.2 Activity structure

Existing research has identified strategies for implementing effective STEM learning experiences in face-to-face contexts. Wan et al. (2021) conducted a systematic literature review into STEM education for children aged three to eight. In terms of activity structure, they found activities could be broadly categorised into the following: programming robots, traditional engineering design, digital games, and comprehensive approaches. While their review was thorough in its explanation of each approach, only eleven studies fit their criteria, and no studies appeared to explore *creativity* as a specific learning outcome. The programming robots approach was found to naturally combine technology and engineering, as children in pre-K through to 2nd grade manipulated robotic kits and wrote programming commands (Kazakoff et al., 2013) while digital games can help preschool children learn about science or maths concepts (Aladé et al., 2016). Traditional engineering design approaches however do not rely on digital technologies for the process of producing. Instead, these activities included following the five-step engineering design process of 'ask, imagine, plan, create, and improve' (Malone et al., 2018), and included challenges such as designing a paper basket to transport wet and dry rocks (Tank et al., 2018). Finally, a comprehensive approach involved children participating in several different activities. For instance, Aldemir and Kermani (2017) engaged pre-K children in three science-based units that also included engineering activities, such as building a bridge, as well as participating in digital games. They reported that engaging in a combination of STEM activities could potentially benefit children's proficiency in mathematics, science, and engineering (Aldemir & Kermani, 2017).

Beyond the four approaches outlined in the review by Wan et al. (2021), it is common for STEM education to adopt open-ended, inquiry-based approaches (Committee on Integrated STEM Education, 2014). Elaborating on this, Larkin and Lowrie (2023) identified teaching approaches typically associated with STEM education: design-based, inquiry-based, project-based, and problem-based learning. While sharing similarities, each approach has its own unique characteristics. Design-based learning usually includes a cyclical, reiterative set of stages. Children are asked to explore a real-world problem, brainstorm solutions, then test, review, and refine prototypes of their solution (Kim et al., 2015; Taylor, 2016; Turkka et al., 2017). This approach encourages children to collaborate, communicate findings, and draw upon previous knowledge (Lovejoy et al., 2021).

Definitions of inquiry-based learning vary (Bybee, 2010), with differences often represented as a continuum from educator-directed to child-centred approaches (Anderson et al., 2019; Calder et al., 2020). Distinguishing inquiry-based learning from project- and problem-based learning is the cyclical scientific method of the 5Es: Engage, Explore, Explain, Elaborate, and Evaluate (Bybee, 2010). Inquiry-based learning can take place over a shorter period of time, and incorporate greater scaffolding by educators compared with project- and problem-based learning (Larkin & Lowrie, 2023).

Project-based learning involves children investigating an authentic problem or challenge for a sustained period of time (Lowrie et al., 2017). Educators support children to create connections with their prior knowledge (Dierdorp et al., 2014). Similarly, problem-based learning involves children working to solve open-ended problems; however the distinguishing feature is that the problem relates to the child's real-life experiences, are posed by the children, and challenge them to think differently when finding solutions (English & Mousoulides, 2015). Problem-based learning normally occurs over several weeks (Albion, 2015). These approaches offer ways for children to demonstrate processes of creative thinking, through intentional provocations and time for creative exploration.

2.4.3.3 Agency and intentionality

Providing a balance between structure and freedom can give learners a sense of agency as they undertake STEM activities. This is mirrored in the balance between play-based learning and intentionality, two approaches advocated in the early years. This is seen within Australia's *Early Years Learning Framework version 2*, which along with play-based learning, advocates "intentionally scaffold[ing] children's understandings, including description of strategies for approaching problems" (Australian Government Department of Education, 2022a, p. 53). The same sentiment has been included in the *Framework for School Age Care in Australia* (Australian Government Department of Education, 2022b). These intentionality strategies include "asking questions, explaining, modelling, speculating, inquiring and demonstrating" (Australian Government Department of Education, 2022a, p. 22). Research has demonstrated the value of including intentionality within early years STEM activities (Eshach & Fried, 2005; Kallery, 2004; Lippard et al., 2017; Murcia & Oblak, 2022). In a systematic literature review into engineering thinking in children aged 5 or under, Lippard et al. (2019) found that "intentionality is crucial in promoting children's engineering thinking" (p. 465). Balancing intentionality with agency was explored in a Western Australian study by Fairhurst et al. (2023) whose Year 5 participants said they preferred when classroom teachers did not give them answers immediately, but rather gave them opportunity to trial a range of solutions.

This aligns with research by Lombardi et al. (2021) who noted the significance of giving learners agency in STEM education to enable them to leverage prior knowledge, create and experiment, and engage in hands-on investigation.

2.4.3.4 Physical resources

Providing hands-on resources for young children to engage with is an important component of early childhood learning, STEM education, and creative development (Beghetto & Kaufman, 2014; DeJarnette, 2018). The use of familiar materials such as common household and construction items like pipe cleaners, alfoil, and masking tape have been advocated for by Campbell et al. (2018) in their investigation into STEM in early year pre-school centres. Similarly, Year 5 children interviewed by Fairhurst et al. (2023) spoke of enjoying hands-on learning, and wanted more opportunities to physically create and play, explaining how it was more effective than, "just like, watching videos or writing stuff down" (p. 17). This pedagogical approach to STEM education aligns with those supporting creativity, by providing children the opportunity to explore, create, and investigate with tangible resources to create solutions.

2.4.3.5 Constraints

Constraints to STEM education include concerns raised by educators around insufficient resources to use during STEM activities (Jamil et al., 2018; John et al., 2018; Park et al., 2017). Another unexpected constraint that emerged during a study by Hudson et al. (2015) was that Year 4 students encountered challenges with fine-motor coordinator tasks when working with physical materials, for instance trying to construct a frame using pipe cleaners, leading to pressure on educators to provide sufficient support.

Aside from resource constraints, other constraints have been raised by educators. In their systematic literature review, Wan et al. (2021) found the most frequently mentioned challenge to implementing STEM education was time constraints. This was also found to be a challenge among the educators interviewed by Fairhurst et al. (2023). This is problematic, given that having time to explore, create, and innovate is crucial in early years learning and creative development

(DeJarnette, 2018). Additionally, educators have identified a lack of professional development leading to low self-efficacy to implement STEM in classrooms (Park et al., 2017). Regarding collaboration, it has been found that while children are engaged when working independently on STEM designs, they can lack confidence in their own ideas.

2.4.4 Home-based STEM learning experiences

Home-based learning is a phenomenon that encompasses the period of children being at home in early years learning with parents. It also has more recently referred to children being at home while engaging in emergency remote learning. Previous studies have found that parental engagement has positive effects on children's achievements in STEM (Ing, 2014; Perera, 2014), particularly when they support and promote key skills such as persistence, attention, and problem-solving (Lang et al., 2014; Milner-Bolotin & Marotto, 2018; Strawhecker et al., 2023). Similarly, Tippett and Milford (2017) found during a home-based study that carefully designed STEM activities can result in positive experiences for preschool-aged children. Further, parents surveyed in Tippett and Milford's (2017) study noted an increase in their children's STEM skills of questioning and exploring following their involvement in early childhood STEM education. Similarly, Tay et al. (2017) found that following STEM interventions, pre-K children were more receptive to situations deemed as challenges. These examples collectively highlight the positive impact of children engaging in STEM learning experiences at home with the supervision and participation of their caregivers.

It was found during emergency remote learning that caregivers working closely with primary-aged children were able to support their learning potential and provide feedback. As one mother surveyed in a study by Kalman et al. (2023) said, "our interaction and communication have become stronger…We can do more things together" (p. 638). However, educators in the same study felt that not every home could be successfully turned into a learning environment, due to the "order of each home, the resources available, parental attitudes, and student behaviours" (p. 637). To create a successful physical learning environment at home, parents in the survey reported providing a quiet, personal space with a table for materials to be set-up on was most beneficial.

2.4.5 STEM online educators and theatre performances

While STEM learning experiences can occur in a classroom setting under the direction of the classroom educator, they are also delivered through STEM online educators. There are countless STEM outreach programs that promote connection with STEM industries, including citizen science activities, coding clubs like CoderDojo, and challenges such as STEM video game challenge. Further, galleries, libraries, archives, and museums (GLAMs) are known for providing a wide range of STEM activities (Timms et al., 2018). These outreach activities can have positive learning outcomes for children. For instance, in a study by Vennix et al. (2017) focusing school-aged students, participants held positive perceptions of the outreach learning environment compared to their regular school science course. From a creativity perspective, Davies et al. (2013b) found in their systematic literature review into children's creativity, that creative environments were also characterised by collaboration and involvement with outside agencies, either by visiting those venues or bringing experts into the classroom.

It has been established that viewing live theatre performances can engage young children, drawing emotional responses from them, such as empathy (Jackson & Vine, 2013; Jayakumar, 2020; Klein, 1995; Schiller, 2005). Research conducted by Schiller (2005) with young Australian children found that watching live theatre performances captured their interest, was memorable, and drew emotional responses. For instance, one of the participants said, "my friend had tears in her eyes, but they weren't running down" (p. 548) while watching a live performance of *Brundibar.* Similarly, results from an empathy study with young children by Klein (1995) revealed that they cared and felt compassion for characters observed during live theatre productions. In turn, this encouraged children to respond creatively, using their imaginations to plan, organise, and create art themselves (Schiller, 2005). The use of live theatre performances by STEM outreach programs are opportunities to engage children and provide a foundation from which they can foster their creative thinking.

2.5 ONLINE LEARNING

The following section explores online learning, specifically definitions of online learning; benefits; online learning pedagogies; challenges; and online learning in an early years context.

2.5.1 Defining online learning

While there has been an acceleration in the number of children engaged in online learning over recent years, there is still much to learn (Barbour et al., 2020). Specifically, there is a gap in understanding around the pedagogical strategies that foster positive learning outcomes aligned with early childhood education policies. Distance education has evolved through various stages: correspondence; broadcast radio and television; open universities; teleconferencing; and the Internet (Saqlain et al., 2020). However, online learning in a K-12 context began in the late 1990s due to an evolution in technology which made it feasible (Clark & Barbour, 2023). Specifically, the rise of the personal computer and their connectivity to the Internet and various platforms and apps created possibilities by offering higher quality interactions and multimodal communication (Borup & Kennedy, 2017; Buckingham, 2017). As a result, countries including the United States, Canada, the United Kingdom, Australia, and New Zealand had their own K-12 online learning programs well before the COVID-19 pandemic (Ames et al., 2021; Barbour & Reeves, 2009). The affordability of hardware, a growing number of learners with individual learning needs, and societal changes have all contributed to the rise in online learning around the world (Barbour, 2018; Davis & Roblyer, 2005).

Several terms are often used interchangeably with online learning. These have previously included: *virtual schooling, e-Learning, cyber learning, online distance education, electronic learning,* and *web-based learning* (Saba, 2005). More recently, terms such as *emergency remote teaching,* and *remote learning* (Bozkurt & Sharma, 2020; Daniel, 2020; Hodges et al., 2020) have been used in relation to the COVID-19 pandemic. Common to each of these terms is that they "refer to the delivery of education in which digital technology and the Internet are used to deliver instruction and to facilitate communication among participants" (Saqlain et al., 2020, p. 39). However, a key distinction of emergency remote teaching is that rather than be planned from the beginning for online delivery, as online learning is, emergency remote teaching instead is a:

> temporary shift of instructional delivery to an alternate delivery mode due to crisis circumstances. It involves the use of fully remote teaching solutions for instruction or education that would otherwise be delivered primarily face-to-face and that will return to that format once the crisis or emergency has abated (Barbour et al., 2020, p. 6).

Arguably the most prominent example of emergency remote teaching occurred during the COVID-19 pandemic. At its peak, more than 1.6 billion children and youth were affected by school closures, and of these, 463 million children were unable to access remote learning (UNICEF, 2022). Understanding the distinction between online learning and emergency remote teaching highlights the complexities of online education, assisting with more informed learning approaches.

There are two forms of online learning, synchronous and asynchronous. Synchronous online learning involves real-time communication between educators and learners, whereas asynchronous occurs in delayed times and does not rely on simultaneous access (Doz et al., 2023; Johnson, 2006; Oztok et al., 2013). Examples of synchronous online learning includes learners and the educator joining a live Zoom, Webex or Microsoft Teams meeting, whereas asynchronous could include learners accessing a platform such as Blackboard to download pre-recorded videos and activities.

2.5.2 Benefits of online learning

There are several reasons why online learning can be beneficial to learners. Firstly, online learning offers access to education for learners who need flexible schedules due to disabilities or disciplinary problems; who are home schooled; or who have limited curriculum in their own school (Archambault et al., 2022; Saqlain et al., 2020). Further, key opportunities arise for children living in regional and remote areas. It is understood that attracting and retaining qualified educators is an ongoing issue in regional and remote areas (Monk, 2007), and it can also be challenging and expensive for these schools to offer specialists for small numbers of learners (Stevens, 2013). Therefore, online learning provides the potential to offer a wide range of learning opportunities through highly-qualified educators (Jimerson, 2006). With this increased demand comes the need for skilled educators who can understand and apply the principles of effective online pedagogy (Archambault et al., 2022).

2.5.3 Online learning pedagogies

The following section provides an overview of online learning pedagogies, including active learning; building rapport and engagement; questioning; technology considerations; and synchronous vs. asynchronous learning.

2.5.3.1 Overview

Online pedagogy consists of the methods, techniques, and strategies used to teach content via the Internet (Brennan, 2003). Research into online learning has illustrated that the skills and knowledge required to teach in a face-to-face classroom learning environment differs greatly from those required in an online learning environment (Pulham & Graham, 2018). In delivering effective online learning, educators must bridge the gap between time and space to foster a positive relationship, understand learner needs, and tailor the learning so that it is both relevant and accessible to learners (Borup et al., 2020; McCombs, 2001).

2.5.3.2 Active learning

There are numerous studies, theories, models, standards, and evaluation criteria that focus on quality online learning (Barbour et al., 2020). For example, a study by Hew (2018) reviewed ten highly-rated Massive Open Online Courses (MOOCs) used in higher education and identified four contributing factors of effective online learning: problem-centric learning, active learning, course resources, and instructor attributes. Archambault et al. (2022) reviewed and cross-referenced the literature related to online and blended teaching competencies in schools and identified five key pillars as essential elements of effective online pedagogy: build relationships and community; incorporate active learning; leverage learner agency; embrace mastery learning; and personalise the learning process.

Incorporating active learning is one of the characteristics that is common to these various models. Active learning involves learners making connections with the content. Archambault et al. (2022) described active learning in STEM online learning environments as offering learners:

> the opportunity to leverage their prior knowledge and experiences to make direct observations, create and manipulate scientific models, and engage in domain-specific practices as scientists would. Such practices include solving open-ended problems, analysing data, running experimental investigations, and creating plausible explanations (p. 184).

Further, learners benefit from developing their own agency and taking responsibility for their learning (Archambault et al., 2022). Within a face-to-face classroom environment, educators scaffold and assist students to manage content, monitor what needs to be done, oversee the learning environment, promote student reflection and evaluation, and provide ongoing feedback (Ley & Young, 2001). Within an online learning environment, learners need to use greater self-regulated learning strategies to stay on track, and seek assistance when necessary, while the educator must be strategic in the actions they take to help learners develop and foster self-regulation, and build their independent learning skills (Archambault et al., 2022). The other common characteristic of these models is that of relationship building between educator and learners.

2.5.3.3 Building rapport and engagement

Building a positive relationship between the educator and the learner is vital to effective online pedagogy (Borup et al., 2020; Dyer et al., 2018; Garrison & Arbaugh, 2007). While engagement is often positively related to many student learning outcomes (Fredricks et al., 2005; Meyer, 2014), in online education engagement is even more important as it can be more difficult to engage with learners (Bolliger & Martin, 2018; Hew, 2018). Firstly, it is essential for the educators themselves to be engaged (Deschaine & Whale, 2017; Hew, 2018; Pittaway, 2012). The educator needs to create and support a learning community in which learners feel connected (Kaufmann & Vallade, 2022; Picciano, 2002). Within a face-to-face classroom environment, creating bonds may come naturally, whereas in an online environment it may take deliberate effort to know the learners (Borup et al., 2020) as the limited physical interaction can pose challenges for building rapport and personalising interactions (Ong & Quek, 2023). Negrette et al. (2022) found in their study into early years educator perspectives during the COVID-19 pandemic in Hong Kong that educators needed to adapt and seek new strategies to get to know learners. The educators interviewed noted how it felt different to be delivering online as opposed to in person, with one commenting, "this year, when I sing, I feel very alone on the screen, and so that's what made me feel a bit awkward" (p. 546). Ong and Quek (2023) found secondary school students appreciated it when educators paused and checked their understanding, and patiently addressed their doubts.

Finally, the role of peers is important in engaging others within an online learning environment. "Peer support and engagement are likely to be reciprocal" (Fredricks et al., 2005, p. 76) with positive peer support like praise or encouragement increasing learners' motivation (Montgomerie et al., 2016; Rautanen et al., 2021), and enhancing their self-esteem (Tait, 2000). By comparison, negative peer relations can reduce learner engagement (Rautanen et al., 2021). The literature demonstrates the importance of learners developing positive relationships with both their educator and other learners while in online learning environments.

2.5.3.4 Questioning

Wang et al. (2023) identified that adult learners in online learning environments do not often spontaneously interact with the educator, and often fail to find proper time to ask questions. Strategies asserted by Lakhal et al. (2020) to overcome this include educators having remote lecturing skills such as talking to the webcam, pausing for a while during a lecture to invite questions, or inviting silent learners to participate by calling their names. Further, due to the small window size of streaming videos on a computer screen, educators often rely heavily on verbal language and positive tone as a strategy to engage learners, like warm greetings (Lakhal et al., 2020), using open and inclusive language (Romero-Hall & Vicentini, 2017), joining the meeting room earlier to welcome learners (Bower et al., 2015), setting aside time for chit-chat (Ong & Quek, 2023), and demonstrating a sense of humour (Hew, 2018; Pentaraki & Burkholder, 2017). They can also help foster a positive socio-emotional climate by providing support and encouraging learners (Kurt, 2022), incorporating non-verbal cues like using smiles or onscreen emoticons to establish immediacy with learners (McArthur, 2022). This all highlights the nuances of online learning environments, and the unique strategies that need to be considered by educators teaching in this way.

2.5.3.5 Technology considerations

To create an effective online learning environment that allows for collaboration, the necessary infrastructure must be available, such as devices with Internet connection, cameras, and microphones. Aside from stable Internet connection and a device, research has emphasised that audio must be clear because unwanted noise could affect a learner's concentration (Cloonan & Hayden, 2018; Conklin et al., 2019; Cunningham, 2014). Further, keeping the camera on helps learners visually indicate their attendance and participation (Ewing & Cooper, 2021; Wang et al., 2018). The space should also be quiet without distractions (Cloonan & Hayden, 2018; Olt, 2018; Vale et al., 2020; Zydney et al., 2019). Wearing headsets with a built-in microphones helps minimise interference from noisy surrounding areas for adult learners (Angelone et al., 2020; Lakhal et al., 2020). These strategies acknowledge and highlight the unique considerations to be made when learning online as opposed to a physical classroom environment.

2.5.3.6 Synchronous vs. asynchronous

Research consistently highlights the advantages of synchronous online delivery, in terms of its ability to offer instant feedback, improve educator-learner interactions, and promote peer collaborations (Maor et al., 2023; Ong & Quek, 2023; Wang et al., 2023). Platforms such as Zoom have been specifically identified as effective in increasing learners' motivation in primary school (Maor et al., 2023). Often, synchronous delivery is used to emulate what happens in the face-to-face classroom environment (Guo, 2020; McArthur, 2022).

Regarding asynchronous delivery, secondary school participants in a study by Ong and Quek (2023) felt that asynchronous lessons lacked interactions, they felt more disengaged, and were limited in their ability to ask questions immediately. However, the systematic literature review into online learning experiences conducted by Bond (2020) found no clear difference between using asynchronous and synchronous methods, "but rather it was the quality of the teaching that was the most important, with a focus on clear explanations, scaffolding, and providing effective feedback" (p. 193). As such, educators currently make use of both forms of communication, with little guidance as to which method is most suitable in an early years' context.

2.5.4 Challenges with online learning

Numerous challenges have been identified with online learning. For example, Doz et al. (2023) identified seven categories of primary and secondary school student difficulties according to educators: problems in using technologies; impoverishment of social relationships with educators and peers; difficulties regarding independence, motivation and attention; lack of support from family members; and problems with routine adherence. Additionally, there is an abundance of research around the challenges of online learning, much of it was in the context of emergency remote learning during the COVID-19 pandemic. For instance, the perception that online learning was "boring" or "passive" prevailed among numerous study participants (Dong et al., 2020b, p. 7; Inan, 2021, p. 7).

A lack of feedback and responsiveness has been identified as a key challenge for online learning. Secondary school learners involved in a study by Ong and Quek (2023) stated that they enjoyed interacting and engaging through group work and discussions, as well as with their teacher; however, there were fewer opportunities for these interactions online. Learners also noted the lag time in receiving help and how difficult it was to raise questions in the middle of a live online lesson (Ong & Quek, 2023; Russo, 2021). Compared with the face-to-face learning environment, online learning did not provide for the same level of educator guidance (Barbour, 2018). Educators themselves have identified the inability to provide individualised support as a problem of online delivery across several studies and countries (Phillips et al., 2021; Woltran et al., 2021).

Technology constraints have been consistently raised as an issue for implementing successful online learning (Adedoyin & Soykan, 2023; Ong & Quek, 2023; Ozudogru, 2021; Russo et al., 2021). Although technology is a tool that enables educators to deliver content and learners to communicate with one another, it becomes a limiting factor when it does not work as expected, such as not providing a stable Internet connection (Wang et al., 2023). These impacts were noticeable during COVID-19 emergency remote teaching, where Australian educators reported that unreliable Internet impacted children's learning and engagement (Fray et al., 2022; Page et al., 2021; Van Bergen & Daniel, 2022). Findings by Fray et al. (2022) in particular, acknowledged that educators in regional and remote schools of Australian faced additional burdens related to unreliable Internet access.

Further, students' lack of focus has been identified as another online learning challenge (Raja & Nagasubramani, 2018), both during COVID-19 emergency remote learning and previous distance learning (Adnan & Anwar, 2020; Almazova et al., 2020; Lauret & Bayram-Jacobs, 2021; Muilenburg & Berge, 2005; Turner et al., 2020; Twenge & Campbell, 2018). It has been suggested that young learners may lack the metacognitive skills to use various online learning platforms, maintain engagement in synchronous online learning, develop and execute self-regulated learning plans, and engage in meaningful peer interactions during online learning (Barbour, 2018; Broadbent & Poon, 2015; Wang et al., 2013). Finally, a challenge for families and caregivers was the struggle to stay engaged with their child's school and learning during the COVID-19 pandemic, given their need to balance other responsibilities as well as insecurities about content knowledge, and emotional implications and effects of emergency remote learning (Garbe et al., 2020; Negrette et al., 2022). While the literature presented provides a foundational understanding of effective pedagogies and considerations for online learning, it is crucial to explore how these principles apply within the unique context of early years education.

2.5.5 Online learning in early years context

The previous section provided a comprehensive overview of current effective pedagogies and challenges relating to online learning. However, the findings shared thus far have almost exclusively been drawn from studies involving older learners in university environments. They provide an important overview and context for the nature of online learning in general, but do not necessarily provide specific insight into online learning in an early years context. Where K-12 students have been included in the research, secondary students have been prioritised (Bond, 2020; Harvey et al., 2014; Maslin et al., 2023). This is exemplified by the findings from Bond (2020) into the global published literature on COVID-related online learning.

Of the 80 studies published that focused on K-12 settings, secondary schools featured in 78% of the articles; primary schools in 62%; and kindergartens in just 10%. Of these, only one article exclusively focused on the kindergarten context. The limited amount of research regarding online learning in the early childhood space results in limited understandings about its impact or potential for children's learning.

Understanding the differences in how younger children learn, and the different expectations placed upon them is important. Delivering online learning to them in the same as an older students could hinder their learning experiences (Yan et al., 2021). Children's voices are often underrepresented in educational research, and it is important to include them further as this helps develop knowledge that can make these areas of education more robust (Keaton & Gilbert, 2020). The following is an extract, shared with permission, from the systematic literature review conducted by Maslin et al. (2023). This review explored the challenges and opportunities for educators in fostering young children's creativity in online learning environments.

2.5.5.1 Systematic Literature Review

The aim of this systematic literature review was to examine the challenges and opportunities for educators in fostering young children's creativity in online learning environments. To achieve this, the research was broken into two phases. In the first phase, multiple database searches were completed to extract research articles about young children learning online. In the second phase, multiple keyword searches were conducted on the extracted articles to identify references to creativity. The keywords used in this search were sourced from the *A-E of Children's Creativity* framework and included characteristics of children's creative processes: agency, being curious, connecting, daring, and experimenting.

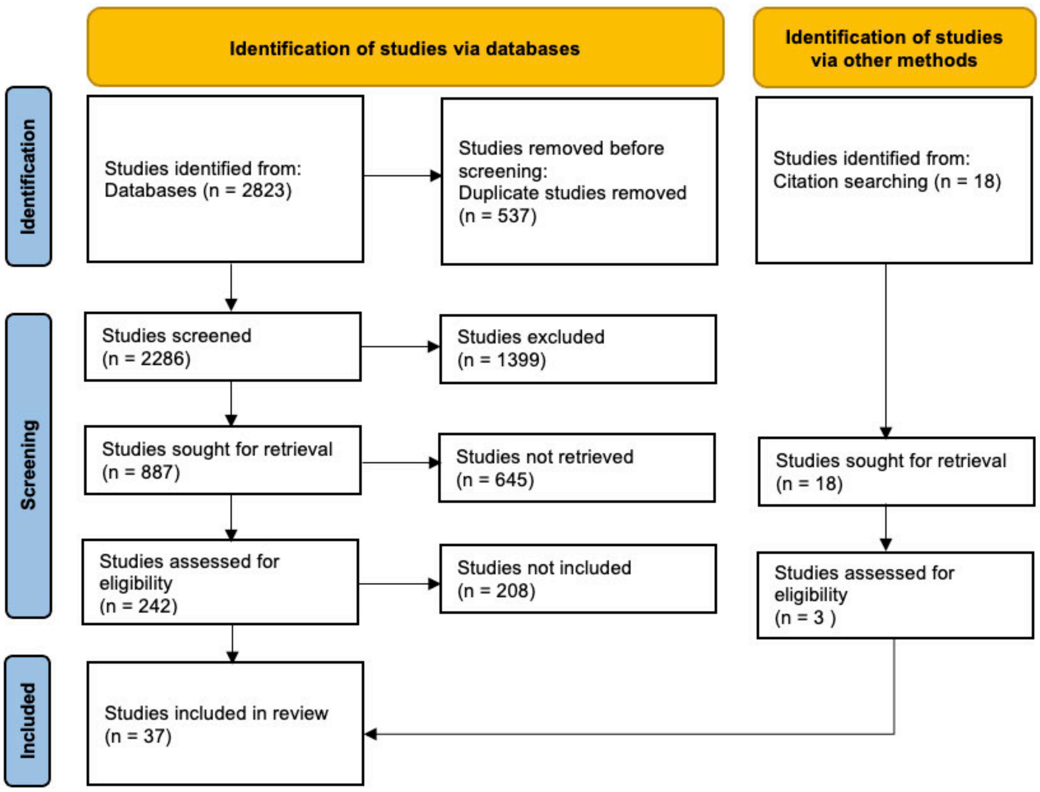
In phase one, searches were carried out in Scopus, Proquest, Web of Science, Emerald, Informit and PsychInfo (OVID) databases. The following search terms were applied when executing the search: ("k-12" OR "Children" OR "Early Childhood" OR "Primary School" OR "Elementary School" OR "Early Learning" OR "Nursery" OR "Preschool" OR "Pupil") AND ("Online pre/0 Teaching" OR "Remote Teaching" OR "Online Education" OR "Distance Education" OR "Remote Education" OR "Online Learning" OR "Distance Learning" OR "Home Learning"

OR "Remote Learning" OR "Online Distance Learning" OR "Online Schooling") NOT ("University" OR "Higher Education" OR "Pre-service").

A citation search of the key text (Murcia et al., 2020) was also conducted to identify additional articles which may not have been picked up from the database search. The structure of this review was guided by the *Preferred Items for Systematic Review and MetaAnalysis (PRISMA) Statement* (Moher et al., 2009). Criteria for the database searches included peer-reviewed journal articles published worldwide in English from 2010. The articles needed to report on empirical research using any methodology and the content of the research was to focus on the educational experience of young children aged 4 to 8 in online learning environments. Figure 2.3 provides a graphical representation of the process undertaken.

Figure 2.3

Selection of articles



Using this search strategy, 2841 articles were delivered. Duplicate entries (537) were removed, and the remaining articles (2304) were screened for suitability based on their title and abstract. Following this, the full text of remaining articles (895) was evaluated. Those containing exclusion criteria were removed, such as articles where participants fell outside the age parameters, or where the study focused on young children's wellbeing rather than learning. As a result of this process, a total of 37 studies remained for analysis.

2.5.5.2 Results

The research included in this systematic literature review were coded in several ways to extract findings relevant to the research question. These findings are outlined below.

Year of publication

It is significant, but perhaps unsurprising, that most articles have been published since 2020. Prior to the COVID-19 pandemic, only three of the 37 articles explored teaching young children in online learning environments. There was a spike in 2020 (seven) followed by a spike in 2021 (27). This suggests that online learning for young children has not been a topic at the forefront of practitioners', and therefore educational researchers', minds until the COVID-19 pandemic. The sharp spike in 2021 could be attributed both to the practicalities of conducting research, as well as the growing concern about the impact on young children's education as the pandemic continued into its second year.

Location of studies

Coding by location revealed that although studies emerged from around the world, a significant proportion derived from the USA. Specifically, 13 of the 37 studies (35%) were undertaken in the USA, with a relatively high number also occurring in Turkey (22%). Overall, articles originated from all continents. It is unsurprising that research has emerged from so many different countries, given the worldwide nature of COVID-19 pandemic-related school closures.

Research participants

While the focus of the articles retrieved centres around the learning of young children, most participants were educators and caregivers. Of the 37 articles, 27 (73%) included educators, 12 (32%) included caregivers, and three (8%) included children as research participants. Several studies included a mixture of two or more types of participants. The challenges with engaging children as research participants and the rapidness with which researchers were collecting data during the COVID-19 pandemic perhaps explains the low number of children actively involved in the research.

Research methodology

Of the 37 articles, eight (22%) employed quantitative methods, 22 (59%) employed qualitative methods and seven (19%) employed mixed methods. The reason that qualitative methods dominate could be attributed to their ability to observe and learn about experiences.

Technology used for delivery of online learning to children

Coding the retrieved articles provided opportunity to collate data about the different strategies and experiences of online learning. Data from the results of the included articles were coded to identify which technology tools were used in early childhood contexts. These tools were used to communicate directly with children (e.g., using Zoom to deliver a lesson), as well as communicate directly with caregivers (e.g., emailing lesson instructions to caregivers). The results are listed in Table 2.1.

Table 2.1

Technology used in delivery of online learning to young children

Technology	Frequency
Zoom	11
Email	9
Google Classroom	7
WhatsApp	6
Phone call	6
Text messages	4
Unknown video conferencing	4
Pre-recorded video	3
Facebook	2
Google Meet	2
Microsoft Teams	2
YouTube	2
Canvas	1
Dojo	1
Excel	1
Instagram	1
Loom	1
Maths Online	1
PowerPoint	1
Unknown digital learning system	1
Skype	1
WeVideo	1

Table 2.1 reveals that video conferencing, particularly Zoom, emerged as the most frequently used platform. This could be attributed to the synchronous nature of Zoom, and how it somewhat resembles a familiar face-to-face learning environment. This was illustrated by the response of one educator, who explained that video conferencing was chosen to ensure that children "feel as if they were in their classroom, they could see the table and chairs and the charts" (Dayal & Tiko, 2020, p. 344). This aligns with research presented earlier around the benefits of synchronous communication for older learners. The high usage of email could be attributed to its prevalence, offering a way of communicating that did not involve new learning for educators and families.

Frequency of the term 'creativity'

Table 2.2 lists the frequency of references to 'creativity' in the articles. Keyword searches were carried out across the 37 articles, searching for the keywords listed. This includes the characteristics, and words associated with each characteristic, as outlined in the *A-E of Children's Creativity* framework. Not included in the table are references to the keywords out of educational context. For example, where the authors stated in their methodology section, ‘the *questioning* of participants took place over a one-month period,’ this use of the term *questioning* was not counted. Likewise, the term *resilience* was used in the context of children displaying resilience in the face of COVID-19-related trauma, but not in an educational context. As such, these uses of the term were eliminated.

Table 2.2

Frequency of ‘creativity’ terms included in articles

Term	Frequency (No. articles)
Creativity *Creativity, creative thinking, creative*	10
Agency *Agency, self-determination, purpose, autonomy, personal choice*	4
Curious *Curious, questioning, wondering, imagining, exploring, discovering*	3
Connecting *Connecting, patterns, reflecting*	3
Daring *Daring, persisting, resilience*	0
Experimenting *Experimenting, investigating, tinkering, solving problems*	3

The findings of this search highlight how infrequently creativity was mentioned explicitly by researchers and participants.

2.5.5.3 Themes identified

Several themes emerged in relation to challenges and opportunities for educators in fostering young children’s creativity in online learning environments: reduced responsiveness and opportunities for challenge; young children’s age and abilities; creativity and play; opportunities through activities and technology features; and opportunities through online mathematics activities.

Challenges for fostering creativity in online learning environments

While creativity was rarely mentioned explicitly in the articles, several characteristics of creativity were referred to. The notion of providing children with agency emerged across several studies, as did giving them opportunities to be curious, make connections, be daring, and experiment. Often these characteristics were mentioned in the context of a ‘challenge.’ It emerged that educators found it difficult to facilitate these characteristics in an online environment. They specifically noted the lack of differentiation delivered during online learning, instead sometimes re-teaching existing concepts or adjusting activities, so they were less challenging (Inan, 2021; Munastiwi & Puryono, 2021; Russo, 2021; Soltero-González & Gillanders, 2021; Kristy Timmons et al., 2021). Research findings suggest the lack of responsive feedback in online environments hindered opportunities for children to pursue challenging and creative tasks. Educators noted the nature of online platforms and technology issues made it difficult to interpret and respond to each child's learning needs. Russo (2021) summarised accordingly, "the broad consensus was that encouraging productive struggle was far more problematic in a remote learning setting compared with the classroom" (p.6). One educator explained how in a physical setting they can encourage the struggle, "[educators] know when to come in and provide a prompt and we know when to hold a prompt back" (Russo, 2021, p. 7). This was a consistent theme, with one educator from the study by Inan (2021) commenting, "I do not think that online education provides educators an opportunity to observe and listen to children pedagogically" (p.8), and another stating, "I found that online learning lacks interaction, and I cannot get children's feedback in the same way as face-to-face learning" (Hu et al., 2021, p. 1523). By being responsive to children, educators can foster a learning environment that allows children to experiment, make connections and be daring, characteristics essential to creativity. However, these studies suggest that educators found this practice challenging in an online environment and children's creativity may have been negatively impacted as a result.

The review of the literature indicated that the capacity of young children to engage independently in online learning activities could be a barrier in fostering creativity. Several researchers noted the age of children made it challenging for them to be given the same level of agency as in a classroom environment. Educators reported that the experience of online learning gave way to a level of distraction for the child and it was challenging to hold their focus (Soltero-González & Gillanders, 2021; Uzun et al., 2021). For example, educators in the study by Uzun et al. (2021) reported "[they] were so distracted… with the TV turned on, or they had siblings there or someone else" (p. 21). In the study by Lau and Lee (2021), 'children's lack of focus/interest' was the most frequently rated difficulty, selected by nearly 74% of kindergarten parents. Another summarised, “as the age group gets smaller, they cannot focus" (Inan, 2021, p. 7). Further, it was reported that young children struggled to complete tasks independently, with this being the most common difficulty cited by parents in a study by Stites et al. (2021). Similarly, Yan et al. (2021) noted “the low usage of the independent learning methods [in online learning environments] in early-school-year students may reflect their inability to engage in independent learning” (p. 2049).

The consequence of these experiences is a lack of opportunity for creativity to be evidenced, due to the need for tasks to be simplified or requiring extensive input from the caregiver. This implies a lessening of the child’s agency, a critical characteristic of creativity. It also suggests that the role of the person being creative increasingly becomes the adult – including the caregiver - rather than the child. The lack of evidence-based strategies to design lessons that provide opportunities for children’s agency and foster experimentation, has resulted in educators adopting varying strategies ad-hoc.

Opportunities for fostering creativity in online learning environments

However, the potential for fostering young children’s creativity online was evidenced in some articles. For example, in the study by Soltero-Gozález and Gillanders (2021), participants described characteristics of the most beneficial activities for young children. These included active participation and child-adult interaction, learning through unstructured play, learning through discovery, and choice. These characteristics align with those of the *A-E of Children’s Creativity* framework*,* indicating there is potential for creativity to be fostered in online learning environments. Further, participants across studies shared examples of activities with implied creative opportunities. For example, agency was afforded when an educator asked students to show something from their home that was the colour brown, “one went and got a jar (of) peanut butter, one girl showed an onion, one boy showed his teddy bear, one went outside and got his brown dog in front of the screen” (Dayal & Tiko, 2020, p. 344). In another example, the features of the technology itself were utilised by an educator who used “the Zoom annotation feature to engage her students in meetings by having them indicate choices on the screen” (Schuck & Lambert, 2020, p. 7). These two examples highlight areas of opportunity, namely, learning more about the *activities* to deliver in online learning environments (i.e., find a brown object), and learning about the *features* of online learning environments (i.e., annotation feature in Zoom) that could help foster creativity.

Three studies explicitly explored the implementation of mathematics activities in an online learning environment (Kalogeropoulos et al., 2021; Russo, 2021; Schwartz, 2012). While the articles did not explore creativity specifically, they identified how children were given agency and opportunities to be daring and experiment. This aligned with what is already known about how mathematics, as a standalone subject or as part of integrated STEM learning, can foster children's creativity (Bybee, 2013; English, 2017; Wan et al., 2021). Kalogeropoulos (2021) reported that the existing philosophy held by the educator and school towards mathematics teaching translated to the online environment. For example, some educators believed prior to online learning that children should have agency in their learning, and that tasks were appropriately challenging and open-ended. Educators also encouraged children to engage in outdoor investigations, play games with their family, and work independently on tasks. This study suggests the attitudes held by the educator may be as important as the actual learning environment in influencing how online lessons are delivered. This may support the existing evidence that 'creative' educators hold positive views towards creativity and that in turn helps facilitate the development of children's creativity (Davies et al., 2013a).

In one of the three studies that occurred prior to the COVID-19 pandemic, Schwartz (2012) compared the online and offline completion of a mathematics game among Year 1 children. Schwartz reported "the online students [had] more varied and thorough representations of their work...[and] the online context afforded deeper use of the practices of doing mathematics" (p. 37). This alludes to the potential of online learning environments to allow for further agency, daring, and experimentation. The focus on teaching mathematics in an online environment speaks to the value placed on the mathematics discipline, and the established research field of mathematics pedagogy. Creativity may be an implicit outcome of effective mathematics activities regardless of whether they are delivered face-to-face or online.

Opportunities associated with play-based learning emerged as a consistent theme. Specifically, three studies explored play as a central research objective (Gürbüz, 2021; O'Keeffe & McNally, 2021; Soloveva & Quintanar, 2021) while within other articles several educators referenced play as a strategy they employed during online learning. This demonstrates both the researchers' and educators' acceptance of this pedagogical practice and the value they placed on understanding how it can be successfully implemented in different learning environments. For example, in a study of over 1000 early childhood educators by McKenna (2021), 72% reported that play-based learning activities were the most beneficial type of activity during online learning. Likewise, O'Keeffe and McNally (2021) noted that nearly 82% of educators had encouraged parents to play with children at home during school closures. Soloveva and Quintanar (2021) reported on how play changed when online, with considerations such as "children must show all objects [to the] camera" (p. 127). Further, other educators acknowledged "it is difficult to add playful strategies in online teaching. I do not have the experience to do it" (Hu et al., 2021, p. 1525). Prior research has repeatedly confirmed the importance of play for fostering children's creativity and the extent that educators implement play in early education contexts (Craft, 2003b; Tok, 2021). However, what was not acknowledged within the studies of this review was play's connection with creativity.

Scope of research identified by the review

When analysing the selected articles through the lens of creativity, several constraints in the research were noticeable. For instance, it became apparent that creativity has not been an explicit research focus within the context of online learning for young children. The research objectives and research questions for each study showed no reference to the term 'creativity,' nor its associated terms. The focus of the articles instead centred on experiences, attitudes, and perceptions of both educators and caregivers. This is perhaps most succinctly illustrated by some of the article titles:

- *Examining first-grade teachers' **experiences** and approaches regarding the impact of the COVID-19 pandemic on teaching and learning* (Uzun et al., 2021)

- *When are we going to have the real school? A case study of early childhood education and care teachers' **experiences** surrounding education during the COVID-19 pandemic* (Dayal & Tiko, 2020)
- *Caregiver **Perspectives** on Schooling From Home During the Spring 2020 COVID-19 Closures* (Briesch et al., 2021)
- *Young children's online learning during COVID-19 pandemic: Chinese parents' **beliefs and attitudes*** (Dong et al., 2020a)

Further, an analysis of participant responses across the studies showed that fostering creativity in children was not at the forefront of educators' minds. In general, when prompted to discuss their experiences of online learning, participants identified the varying challenges they encountered, as well as the technology they used, and routines they implemented. Participants rarely elaborated on the nature of activities, making it challenging to draw conclusions about the extent to which these activities may foster creativity. Given the importance placed on creativity across early years learning guidelines and policies, it is telling that little explicit attention has been paid to it. However, this perhaps speaks more to context, and the immediate priority of documenting the experiences of an unprecedented global event.

Another constraint of the research that emerged from the articles was the consistent approach to investigate online learning as a singular, homogenous activity. There were few exceptions, with three articles focusing specifically on the learning area of mathematics and three on the pedagogical practice of play-based learning. The result of this research approach were 'conclusive' statements around the effectiveness of online learning. For decades, it has been understood that teaching specific content requires educators to draw upon different pedagogical strategies and knowledge (Shulman, 1986; Van Driel & Berry, 2010). By not acknowledging these nuances, the research examined in this review does not offer educators guidance about quality practice for teaching different content online. Rather, it resulted in many inconsistencies about the experience and effectiveness of online learning. For example, it was reported by Hu et al. (2021) that some educators found online learning a hinderance to interactive learning because "it is difficult for children to have interaction, hands-on exploration, and learning because the ways of online teaching are very different from those of real class teacher" (p. 1525). However, a participant from a study by Timmons et al. (2021) highlighted the potential of online learning by explaining, “I think it’s going to give us the opportunity to show them [the children] independent learning and having questions and how to go about finding the answers on their own” (p. 894). Differentiating between delivery of different learning areas, and different activities, would allow researchers to identify what may or may not work most effectively in online learning environments.

In the few instances where the act of creativity was addressed, it was in reference to adults rather than children. For instance, Anderson (2020) noted that “teachers are rising to the challenge [of online learning] by creating creative assignments” (p. 416). One example presented was that of Chris, a second-grade educator who adapted his traditional lesson by planting seeds on behalf of his class and posting photos on Google Classroom so the children could observe and comment on their growth. The reference speaks to the underlying objectives of the researcher to explore the educator’s experiences, rather than fostering young key competencies. Further observations through the lens of creativity might have offered an evaluation of how such an activity offered opportunities for creative interaction with the children.

Another example of the adult as the creative person was evidenced in the 2021 study by Soloveva and Quintanar who observed children playing with social roles in online environments. They found the role of the adult in the learning was essential, stating “without orientation of an adult, the online play with social roles will never take place…the adult organises the whole activity of the child” (p. 127). This is in line with some research around face-to-face play, which shows the important role the adult plays in developing the quality of play (Devi, 2016; Fleer & Hedegaard, 2010; Li, 2012).

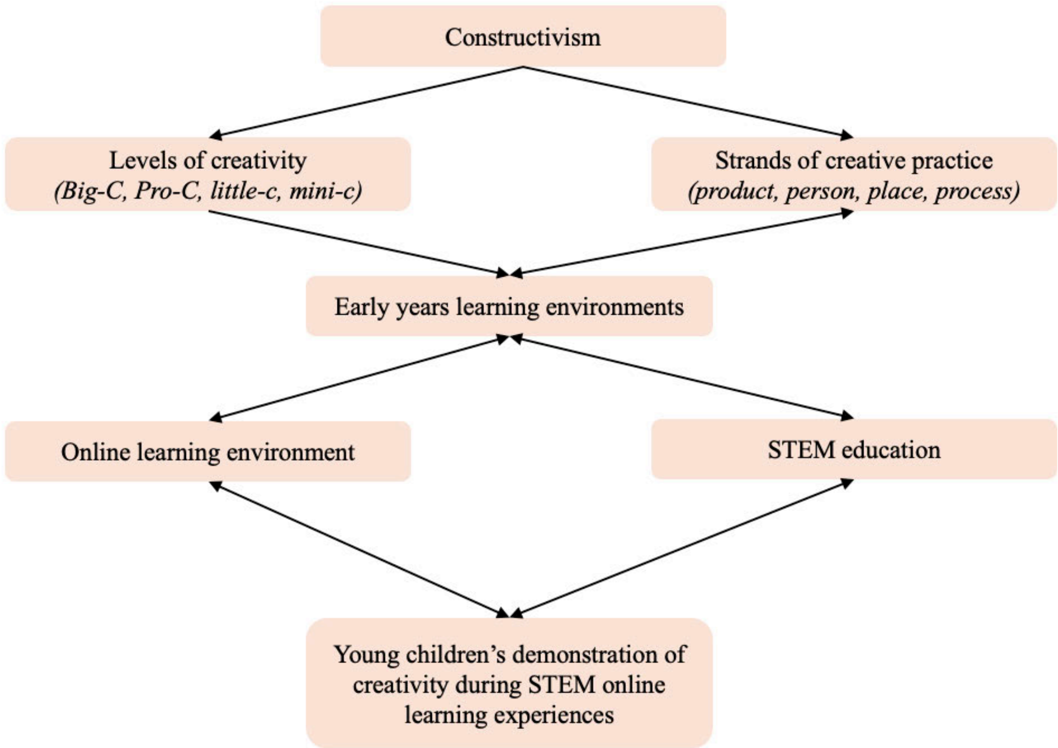
The one example in which children were referenced as the creative person was provided by Dayal and Tiko (2020), who described how “children and educators can demonstrate creativity in virtual sessions” (p. 344). They described a Zoom session whereby educators facilitated Mother’s Day activities online, which included a card-making activity, and a dance item performed online. While children were referenced as demonstrating creativity in the interview, it was notable they were mentioned alongside the educator, and that the activities described still relied heavily on the creative design of the educator. As with the example of Chris, the science educator, a stronger research focus around creativity might have uncovered the extent to which the children were creative agents in this activity including how open-ended or prescribed the art activity and dance choreography were.

2.6 CHAPTER SUMMARY

The literature review has resulted in the creation of a conceptual framework which underpinned the research design and methods of analysis for this study. The conceptual framework is presented in Figure 2.4.

Figure 2.4

Conceptual Framework



This chapter has provided a comprehensive summary of the literature supporting this study. First, the chapter explored what was known about children's creativity, before introducing guiding creativity frameworks. Specifically, the *A-E of Children's Creativity* framework, which will be used as a data analysis tool in this study, was outlined in detail. Enabling elements of a physical environment for fostering creativity were identified. From there, the chapter outlined known strategies for engaging young children in STEM, highlighting that STEM learning offers opportunities for creativity. The chapter then explored online learning, its benefits, and challenges. Finally, the chapter presented findings from the researcher's systematic literature review into what is known about teaching young children in online learning environments.

The review of literature highlighted how STEM education is a suitable way to foster young children's creativity, and the strong overlaps that exist between creativity, STEM education and early years pedagogical strategies. This supports the researcher's decision to use Scitech's STEM sessions as the context for this study. Further, this chapter has outlined the widely accepted approaches to promoting creativity within physical learning environments, while also pointing to the lack of understanding about creativity in online learning environments. Similarly, while there is a growing understanding of effective online learning pedagogies for older learners, little research has explored strategies for younger learners.

The researcher's systematic literature review highlighted further research gaps. For instance, most of the available literature including young children has been published in response to the COVID-19 pandemic, with an emphasis on educator experiences rather than pedagogical strategies. Research has also documented online learning as a singular, homogenous experience rather than exploring the nuances that come with different learning areas or activities. Where creativity was referred to, it was almost exclusively to describe educators as the creative person rather than the child. Additionally, where the characteristics of creativity were referenced, it was often to highlight the challenges that come with providing children agency, and opportunities to experiment and be daring within an online environment. However, there were indications that online learning could present opportunities for children to be creative. Specifically, opportunities arose through the design of the learning activities and the use of the technology features, as well as during mathematics activities. This illustrates the value in conducting research in this space to further examine the potential online delivery offers for children's creativity.

Having presented the literature relevant to this study, the next chapter introduces the research methodology that guided data collection and analysis.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 INTRODUCTION

The previous chapter presented a literature review to contextualise this study within the research fields of creativity, STEM education, and online learning. While research has explored effective online pedagogies for older learners, few studies have included young children and there is a gap in what is known about their online learning experiences. Of the limited studies, no explicit objectives have focused on creativity as a learning outcome. This highlights the value of the current study, which seeks to understand how children's creativity can be fostered during STEM online learning experiences.

The purpose of this chapter is to provide a comprehensive overview and justification of the research methods selected for this study. The chapter begins by providing details about the research design, including the guiding paradigm, epistemology, and methodological approach before discussing the context for the research. Following this are details of the participants and recruitment process, as well as an overview of the research method and data collection procedures for the video observations, semi-structured interviews, field notes, and environment mapping before outlining the data analysis processes. The chapter concludes by discussing measures of research quality, ethical considerations, and limitations of the research approach.

3.2 RESEARCH OVERVIEW

This study sought to identify enabling factors of the learning environment that can help foster children's creativity when participating in STEM online learning experiences. The driving research questions presented in Chapter 1 are reiterated below:

1. How do environmental elements influence children's creativity during STEM online learning experiences?
2. In what ways do children demonstrate creativity while engaging in STEM online learning experiences?

Punch (2013) emphasises that the research design should follow on from the research question, because “how we do something in research depends on what we are trying to find out” (p. 23). The research questions guiding this study call for the experiences of children to be investigated, with terms such as ‘influence,’ ‘demonstrate’, and ‘experiences’ implying a qualitative approach (Merriam & Tisdell, 2015).

A summary of the methodology undertaken for this study is outlined in Table 3.1.

Table 3.1

Overview of research design

Research Overview			
Ontology	Constructivist		
Epistemology	Interpretive		
Methodological approach	Qualitative Multiple case studies		
Context	Western Australian Year 1 classroom Scitech		
Participants	Three case study children		
	Beth: Child (1) Educator (1) Scitech (2) Parent (1)	Chloe: Child (1) Educator (1) Scitech (2) Parent (1)	Jett: Child (1) Educator (1) Scitech (2) Parent (1)
Data collection	Video observations, interviews, field notes, photographs, mapping		
Data analysis	Thematic analysis Multimodal video analysis (narrative analysis) *A-E of Children’s Creativity* framework (Murcia et al., 2020)		

Having presented an overview of the methodology above, this chapter now outlines the research ontology and considers each element of the research overview in detail.

3.3 ONTOLOGY

Ontology is understood as “the nature of reality or of a phenomenon” (Mertens, 2007, p. 213). Widely accepted ontological perspectives adopted by researchers include positivist, constructivist (interpretive), and critical (Carr & Kemmis, 2003; Merriam, 2009). A positivist perspective assumes that reality is observable, stable, and measurable. Meanwhile, a critical approach goes beyond uncovering the interpretation of people’s understandings of their world and aims to critique and challenge (Merriam, 2009). Finally, the constructivist paradigm assumes “reality is constructed by individuals interacting with their social worlds” (Merriam, 1998, p. 6) and that there is no one single, observable reality (Merriam, 2009). The constructivist ontology was chosen for this study because of its objective to explore children's experiences while learning. It is further acknowledged by Merriam (1998) that the researcher brings a construction of reality to the research situation, which interacts with other people's interpretations of the phenomenon being studied. As such, within this study, reality exists according to both the researcher and to individual participants, who bring a unique perspective and approach to online learning. Therefore, every effort was made to understand the perspectives of all involved, including children, their parents, classroom teacher, and Scitech facilitators.

3.4 EPISTEMOLOGY

While ontology is concerned with the nature of reality, epistemology is concerned with the nature of knowledge (Merriam, 2009), specifically "a way of looking at the world and making sense of it" (Crotty, 1998, p. 3). The three main types of epistemology are objectivism, interpretivism, and subjectivism. Objectivism asserts that meaningful reality exists apart from the operation of any consciousness, while subjectivism asserts that the object itself makes no contribution to the meaning (Crotty, 1998). Meanwhile, an interpretive epistemology is characterised by a focus on individual participants and aims "to understand the subjective world of human experience" (Cohen et al., 2018, p. 19). Additionally, it recognises that children express their reality through various modes of communication (Hackling et al., 2014).

An interpretive epistemology was chosen for this study, given its objective to explore factors that contribute to children's creativity during their engagement in STEM online learning experiences. Due to the nature of an interpretive epistemology, the researcher gathered a wide range of perspectives. By incorporating these diverse viewpoints, the researcher aimed to gain a rich and detailed understanding of how the children interacted during the online learning experiences, and the impact these experiences had on their creativity.

To best understand the experiences from the participants' viewpoints, rather than as an outsider (Cohen et al., 2018), the researcher set aside their own assumptions about individuals and contexts, approaching the project on its own terms

(Hammersley, 2012). To facilitate this process, a reflexive journal was used for self-reflection and maintaining a reflexive stance throughout the research project. The importance of researcher reflexivity is discussed in more detail later in this chapter.

3.5 METHODOLOGICAL APPROACH

Educational researchers may draw upon quantitative, or qualitative research methods, or a combination of both. Quantitative research, as summarised by Hammersley (2013), is characterised by testing hypotheses, numerical data, procedural objectivity, generalisation, the identification of systemic patterns of association and the isolation and control of variables. It is guided by a positivist paradigm, underpinned by the belief an objective reality exists independent of the individual (Cohen et al., 2018). In contrast, qualitative research is defined by Hammersley (2013) as:

> A form of social inquiry that tends to adopt a flexible and data-driven research design, to use relatively unstructured data, to emphasise the essential role of subjectivity in the research process, to study a number of naturally occurring cases in detail, and to use verbal rather than statistical forms of approach (p. 12).

Underpinning a qualitative approach is the belief that knowledge is actively constructed by individuals as they engage in, and make sense of, activities and experiences (Merriam & Tisdell, 2015).

Quantitative methodologies frequently employ large-scale surveys in human research, where data is analysed to identify systematic patterns of association (Hammersley & Traianou, 2012). In contrast, qualitative methodologies frequently involve interviews and observations, and are better suited to smaller samples where greater depth of understanding is required (Cohen et al., 2018). A qualitative research approach was chosen for this study, as it was well-suited to the study objectives. Qualitative research gives voice to participants, facilitates multimodal analysis, and allows for in-depth observations of human activities (Cohen et al., 2018; Price et al., 2021). This aligns with the interpretive epistemology guiding this study.

Employing a qualitative approach provided a comprehensive understanding of the children's experiences during their engagement in Scitech's online learning sessions. It provided opportunity for children to share their unique perspectives. Various approaches to qualitative research exist, such as narrative research, phenomenology, grounded theory, ethnography, and case study (Creswell, 2013). The researcher chose to employ a multiple case study design as it allowed for a nuanced exploration of each child's online learning experiences and the unique way in which they were able to demonstrate and deepen their creativity.

3.6 CASE STUDY RESEARCH DESIGN

Stake (2010) suggests that case study research often aims to intimately understand one thing well. According to Merriam and Tisdell (2015), this approach is "an in-depth description and analysis of a bounded system" (p. 39) drawing on data collection from multiple sources (Creswell, 2013). The use of a case study research design provides an opportunity to examine real people in real situations, offering a clearer understanding of a phenomenon. The researcher has the capacity to uncover insights that may be overlooked in numerical analysis (Cohen et al., 2018). As Sturman (1999) asserts, case studies consider the wholeness and integrity of human systems, that necessitate in-depth investigation. As contexts are unique and dynamic, the case study approach can investigate and report on complex interactions of events. It also emphasises the role of the researcher as the primary instrument of data collection and analysis (Merriam & Tisdell, 2015). Additionally, the case study approach is characterised by its "detailed examination of a small sample" (Tight, 2010, p. 337).

A case study design was chosen for this study to facilitate a deep understanding of a small number of children's experience as they participated in Scitech's online STEM sessions. This aligns with the constructive ontology and interpretive epistemology that underpinned the study. Additionally, a case study approach supports the exploration of the two research questions, which seek to understand the ways children demonstrate creativity and the impact of their learning environment. The aim was to identify and unpack the environmental elements that influenced each child's creativity. To do this, data was collected from multiple sources to gather multiple viewpoints (Merriam, 1998). This resulted in an in-depth exploration into the experiences of children and their unique perspectives around online learning and creativity.

3.6.1 Multiple case studies

To capture the complexity and multiple perspectives of the participating children, a multiple case study design was implemented as opposed to a single case study (Cohen et al., 2018; Stake, 1995). Within a multiple case study design, a 'case' refers to a distinct entity with well-defined boundaries (Smith, 1978). In this project, each of the three participating focus children served as an individual case. Recognising each child as a case allowed for a deeper understanding of their unique attributes and experiences. It took into consideration their individuality, and the different ways they demonstrated creativity and engaged in learning experiences. Collecting extensive data for each case provided insights into the experiences and perspectives of the three different children, enhancing understanding of the broader context of online STEM learning activities. Additionally, this approach enabled the researcher to undertake a comparative analysis, highlighting contrasts and similarities among the cases (Merriam & Tisdell, 2015). Finally, this approached allowed for children's perspectives to be heard in-depth. Children's voices are often underrepresented in educational research, however their inclusion helps develop knowledge that can make areas of education more robust (Keaton & Gilbert, 2020).

3.7 CONTEXT

The following section provides context for the study including details around Scitech's involvement; the Western Australian context; the Year 1 classroom; and COVID-19.

3.7.1 Scitech context

Scitech's involvement with this research project was carried out under the guidance of their General Manager, Customer-Facing Delivery. They had regular meetings with the researcher to discuss objectives and identify roles and responsibilities. From here, two Scitech facilitators (Milly and Tahlia – names changed to protect their identities) were assigned to the project. Milly was responsible for delivering the school-based sessions, with support from the Scitech Programs Coordinator. Tahlia was responsible for delivering the home-based sessions, with support from another

Scitech Science facilitator. The researcher liaised with these staff members via email and regular Microsoft Teams meetings to prepare for the sessions. The Scitech staff were responsible for creating the ten sessions, which were carefully designed to incorporate their existing delivery styles. These included a science show, puppet show, classroom STEM workshops as well as activities for an afterschool STEM club. This diversity provided a broad range of STEM online learning experiences for the children to participate in. Each of the sessions were adapted from Scitech's existing programs, so as not to create too much additional work for the staff. It also meant they had the opportunity to evaluate how existing programs could translate to online contexts. As well as designing the structure of each session, Scitech staff gathered the physical materials the children would need for the sessions and shipped those materials prior to the sessions. The school-based materials were sent to the classroom teacher, who set them out in the classroom at the start of each session. The afterschool STEM club materials were sent directly to the researcher, who delivered the packs to the children's homes on the afternoon of each session.

As well as meeting regularly with the researcher, the Scitech staff had Microsoft Teams meetings with the classroom teacher, with the researcher present. These meetings also included Scitech's Senior Digital Content Producer who was responsible for managing the technology of the online delivery, including setting up the live-stream and controlling the camera. These meetings were an opportunity for Scitech to discuss the details of the sessions with the classroom teacher.

During the delivery of each session, Milly presented on-site from Scitech. She was in their theatre for the shows, and in a laboratory for the STEM workshops. While she was the only one on camera, the Senior Digital Content Producer and Programs Coordinator were present to provide support. Likewise, during the afterschool STEM club sessions, Tahlia was the only one on camera, while the Senior Digital Content Producer and the supporting Science Presenter were present off-screen for support. Coincidentally, Scitech had visited the participating school in March, approximately four months before the research project commenced. The visit was part of Scitech's Statewide program, and they performed a science show in the school hall and a STEM workshop in the Science lab. Two of the participating case children, as well as the classroom teacher, were present for this visit.

3.7.2 Western Australian context

The research was intentionally designed to take place within a regional Western Australian context and therefore the findings are particularly relevant for this setting. The decision for this context considered the researcher's accessibility to the participating school, as well as the representation of a typical regional school characterised by average population size and distance from the state's capital city, Perth, and regional hubs. This decision aligns with the descriptions of regional areas outlined in the *Regional Development Commissions Act 1993.* This consideration is important, as one of the key outcomes of this study includes establishing guiding principles for Scitech, and other online education providers, when delivering STEM experiences to regional and remote schools.

3.7.3 Classroom context

The focus children for this study were each in Year 1 at the same regional primary school. Their class was made up of sixteen Year 1 children, with a full-time classroom teacher. The school's leadership team and classroom teacher held positive views towards technology, STEM, and hands-on learning. For the past few years, Investigation Time had been implemented in the lower years. This involved the Year 1 class combining with the Year 2/3 class after lunch to engage in hands-on exploratory activities designed by their classroom teachers. The sessions with Scitech took place in the afternoons during the Investigation Time timeslot. This time was selected as the Scitech sessions were viewed as similar in style to Investigation Time, and as such, would cause the least disruption to the other learning areas. As the Scitech sessions were occurring during this joint Investigation Time, the Year 2/3 class joined the Year 1 class for all Scitech sessions.

3.7.4 COVID-19 context

Western Australia confirmed its first case of COVID-19 on 21 February 2020 and then-premier Mark McGowan declared a state of emergency on 15 March 2020. This led to the state closing its borders to the rest of Australia, and international arrivals quarantining for fourteen days (Jrood et al., 2020). Restrictions were eased in phases, with schools resuming face-to-face education for the start of Term 2 on 28 April

2020 (Perpitch, 2020). By early 2022, the majority of restrictions had been eased, and the state's borders had reopened (Carmody, 2022).

All data collected for this research occurred within the period of July 2022 to December 2022, with minimal disruptions to the research design due to COVID-19. However, precautions were still taken by the researcher and participants, such as maintaining physical distancing where possible during data collection, regular hand sanitising, and staying home if unwell. As the possibility of the researcher or participants contracting COVID-19 could have affected the delivery of the Scitech activities or interview schedule, alternative delivery dates were identified in discussions with the classroom teacher and Scitech facilitators. Additionally, interviews could have been conducted via video conferencing, or postponed until participants/researcher were no longer unwell. Fortunately, no one contracted COVID-19 during the data collection phase. Given the experience of COVID-19 and the brief period of emergency remote teaching in Western Australia in 2020, the research project's significance may have resonated strongly with the adult participants, recognising the potential need for online learning in the future.

3.8 PARTICIPANTS

Case study participants were three Year 1 children from the same class at a regional Western Australian primary school. During the recruitment phase, five children from the Year 1 class volunteered to participate and were involved in data collection during the school-based Scitech sessions. However, the researcher was subsequently advised that one of the children was unable to participate in the home-based sessions as they were moving interstate, and another had conflicting after-school sport commitments. As such, a decision was made to remove these two children from the study and focus on the three children who were present for both the school-based and home-based Scitech sessions.

The three case children were comprised of two females and one male. Each lived in a different suburb within the same regional town. A brief overview of each case child is presented in Table 3.2. This overview was formed from researcher observations as well as extracts from the adult participants' semi-structured interviews.

Table 3.2

Overview of case children

	Beth	Chloe	Jett
Context	Beth is a female in Year 1. She lives with her mother, father, and younger sister. Beth is an out-going, high-achieving child who enjoys arts and crafts.	Chloe is a female in Year 1. She lives with her mother, father, and older brother. They recently relocated from Perth. Chloe is a mature and articulate child, who enjoys learning.	Jett is a male in Year 1. He lives with his mother, father, and two older sisters. Jett is a bubbly and enthusiastic chid, who enjoys building things.
Parent	"Beth's always been really into craft."	"She'll persist with something until she gets it going. She's a fast learner and if she enjoys it, then it just takes off."	"He likes building stuff. He likes to invent things, make things and draw things. Yeah, he is pretty creative."
Teacher – Miss Bird	"I would describe her as creative. She's one that will always go out of her way to create very imaginative stories and amazing pieces of art. I think she's an out-of-the-box thinker. She's got a very individual mind."	"I think she's creative in that she's quite artistic. And she really tries hard to create beautiful pieces of art. She also asks a lot of questions; she is very curious. She loves learning."	"He's very clever and switched on. However, he doesn't ask as many questions and isn't as curious as the other two. He still creates lots of things, so in that sense he is creative."
School-based Scitech Facilitator – Milly	"I found her to be quite creative in her construction activities. But in terms of pushing boundaries, I think she was happy to do that on the artistic level, but not so much with her thinking."	"I feel like she was a lot more confident about her decisions [than Beth]. I feel like in that sense she was happy to make a decision and just follow that track to wherever it led."	"I feel like he had an amount of prior knowledge that he liked to apply and seemed more comfortable within particular constraints. He wasn't necessarily going for wild, crazy ideas."
Home-based Scitech Facilitator – Tahlia	"My first impressions were 'wow, she's a very bright child.' I think she put a lot of pressure on herself, and I believe was quite afraid of failing."	"She was very self-driven. And would just kind of go ahead and start building, but she already had a plan. She was very capable of self-led learning and discovery."	"He had a lot of fun with things. Although he wasn't always working exactly toward the challenge, when he was it was great to see his different ways of thinking."

The Year 1 classroom teacher, two Scitech facilitators, and the three case children's parents also participated in the semi-structured interview process. These adult interviewees were invited to provide a broader understanding of the Scitech experiences and paint a richer picture of each case child. These adults were considered as key participants in the study, but not specifically 'cases.' Additional information has been provided about them below. All names have been changed to protect individual identities.

- *Miss Bird* is the Year 1 classroom teacher. She is in her first year of teaching.
- *Milly* is a Scitech facilitator, who normally delivers live shows in the Scitech theatre.
- *Tahlia* is a Scitech facilitator, who is involved in delivering the Statewide program.
- *Beth's mum* was present for all the afterschool STEM club sessions.
- *Chloe's dad* was present for three and a half of the afterschool STEM club sessions.
- *Jett's mum* was present for three of the afterschool STEM club sessions.

3.8.1 Recruitment Process

Ethics was approved by both the Curtin University Human Research Ethics Committee (HRE2022-0342) (see Appendix 1) and the Catholic Education Western Australia's Human Ethics Research Team (see Appendix 2) prior to recruitment. An initial letter of introduction and invitation to participate in the research was provided to the Principal of the preferred primary school (see Appendix 3). After a positive response from the Principal, the researcher was invited to a meeting with the Deputy Principal to discuss the project in more detail. The school's leadership team was excited and willing for the school to be involved in the study. The Principal received a copy of the *Participant Information Form – Principal* (see Appendix 4) as well as the *Consent Form - Principal* to sign (see Appendix 5). The researcher then met with the Year 1 classroom teacher to talk through the details of the *Participant Information Form – Year 1 Teacher* (see Appendix 6) and answer any questions she had. The Year 1 classroom teacher spoke positively about being involved in the project and signed the *Consent Form – Year 1* (see Appendix 7).

It was during these two meetings that the request for the Year 2/3 class to participate in the Scitech sessions was raised. This was due to the structure of the school's afternoon teaching time, in which the Year 1 and Year 2/3 classes participated in joint Investigation Time. An amendment to ethics was made to both Curtin University and Catholic Education Western Australia to account for the Year 2/3 class as incidental participants of the study. As such, a meeting was also held with the Year 2/3 classroom teacher to share the details of the *Participant*

Information Form – Year 2/3 Teacher (see Appendix 8). The Year 2/3 teacher then signed the *Consent Form – Year 2/3* (see Appendix 9).

The Year 1 classroom teacher distributed the *Invitation to Participate – Year 1* letter (see Appendix 10), *Participant Information Form – Year 1* (see Appendix 11) and *Consent Form – Year 1* (see Appendix 12) documents to the families in her class. Of the sixteen children in the Year 1 class, five returned forms volunteering as case children. Participant parents and the classroom teacher spoke of the children's enthusiasm for science, STEM, technology, Scitech, and being creative. The call to be involved promoted the involvement with Scitech, and as such would likely have appealed to participants who already have an interest in this area.

The Year 2/3 classroom teacher also distributed their *Invitation to Participate – Year 2/3* letter (see Appendix 13) along with the *Participant Information Form – Year 2/3* (see Appendix 14), and the *Consent Form – Year 2/3 (see Appendix 15)*. All children who were not the nominated case children were identified as 'incidental' children. As such, they would participate in the school-based activities and may be filmed as part of the data collection process, however they were not intentionally filmed, nor were they interviewed. At the suggestion of Catholic Education Western Australia's Human Ethics Research team reviewing the initial submission, an 'opt-out' feature was included on the incidental children's consent forms, rather than 'opt-in.' This adjustment greatly reduced the workload for the classroom teachers in chasing up returned forms, as well as the researcher, during the data collection phase. Only one child in Year 2/3 class returned an 'opt-out' form. They still participated in the school-based Scitech activities; however, they were positioned so they were not captured by the video cameras.

The researcher arranged a 'Meet-and-Greet' session with the Year 1 and Year 2/3 classes prior to the first Scitech session. During this session, the researcher shared the *Meet-and-Greet PowerPoint presentation* (see Appendix 16), which introduced both the researcher and Scitech facilitator, briefly explained the purpose of the study and reminded the children of their right to not participate at any time.

The researcher then contacted the parents of the initial five case children via email to introduce herself and outlined what was to come during the study. The parents were contacted towards the end of Term 3 to be given information about the afterschool STEM club sessions occurring in Term 4 and to arrange a time for a home visit Meet-and-Greet. It was at this point that two of the five case children withdrew from the home-based phase, as outlined earlier in this chapter. The researcher visited the remaining three families, to share the details of the afterschool STEM club sessions, and answer any questions the parents had. A *Meet-and-Greet PDF* was provided to all families for their reference (see Appendix 17). These were valuable opportunities to meet the families and feel comfortable being in their home prior to the data collection. It was also an opportunity for the children to feel comfortable with the researcher in their home environment, to meet siblings, and plan logistics for camera placement. The researcher also arranged a formal meeting individually with Milly and Tahlia to explain the research process and provided them with a copy of the *Scitech Participant Information Form* (see Appendix 18). Following this, they each completed the *Scitech Consent Form* (see Appendix 19).

3.9 DATA COLLECTION

To ensure the complexity and entirety of each case is captured, qualitative researchers must draw their data from multiple sources (Merriam & Tisdell, 2015; Stake, 1995; Yin, 2009). The data for this study was collected using a range of methods including video observations, semi-structured interviews, field notes, and environmental mapping. Data collection took place over a six-month period between July 2022 and December 2022. All data was de-identified, and pseudonyms were given to each of the case children and participants (Alderson & Morrow, 2011).

The video observations captured the delivery of each Scitech session. On average, these sessions ran for approximately 45-minutes. A breakdown of the exact duration of each session is presented later in Table 3.3. An initial observation was also carried out in the classroom prior to Scitech's delivery. During this 45-minute observation, the classroom teacher delivered an investigative science session on the topic of light. The purpose of this session was to familiarise the children with the presence of the researcher and cameras in the room, so they felt comfortable with the data collection occurring during the Scitech sessions. Similarly, the follow-up semi-structured interviews with the children about the light session was a chance for the children to become familiar with the interview process.

Each school-based semi-structured interview with the children lasted between 15 and 20 minutes. The interviews with the classroom teacher and Scitech facilitators lasted approximately one hour. The final interview with the children occurred at home with their parents. The children were interviewed for the first 20 minutes, and then the parents were interviewed for the remaining 40 minutes. A breakdown of the exact duration of each interview is presented later in Table 3.6. Both the video observations and semi-structured interviews investigated the impact of the learning environment on children's creativity during the online Scitech sessions. Researcher field notes were written before, during, and after each Scitech session and after each interview. Photographs of the layout of the learning environments were collected to form diagrams in Adobe Photoshop.

An overview of the observed Scitech sessions is presented in Table 3.3, as well as the classroom teacher-led *Light Investigation*. The Scitech sessions are listed in order of delivery.

Table 3.3

Overview of observed sessions

Session name	Session description	Duration (HH:MM)	Type	Facilitator	Delivery platform
Science is Spectacular!	Thirty-minute chemistry-themed demonstrations.	00:39	Science Show	Milly (Scitech)	Microsoft Teams
Bend, Twist, Stretch & Squash	Children investigated items to see if they can be changed by physical force. They also followed directions to make slime.	01:03	Workshop		
Sound Cups	Children explored how sound travels through vibrations. They were challenged to create a 'telephone' using cups and string.	01:00			
What's in the Cup?	Children participated in a scientific investigation, making predictions about the different sounds concealed within cups.	01:10			
DIY Shakers	Children designed and created their own musical instrument ('maker shaker') using materials provided by Scitech.	00:58			

Quiet as a Mouse	Thirty-minute interactive puppet show involved children using their own maker shakers and testing instruments to help music-loving mouse, Racket, placate his sound sensitive neighbour, Melody the cat.	00:44	Puppet Show		
Wind Houses	Inspired by *The Three Little Pigs,* children built a house using provided materials that could withstand the force of wind.	00:50	Afterschool STEM Club	Tahlia (Scitech)	Zoom
Egg Drop	Children built an egg holder using provided materials to protect an egg when it was dropped from a height.	00:43			
Ball Run	Inspired by Rube Goldberg machines, children used provided materials to construct their own simple ball run.	00:42			
Floating Boats	Children used provided materials to construct a boat that could float while carrying cargo.	00:43 (Beth & Jett 00:43 (Chloe)			
Light Investigation	Classroom teacher-led lesson in which children used torches to investigate whether objects were transparent, translucent or opaque. Prepared by classroom teacher	00:41	Classroom Lesson	Year 1 Teacher	Face-to-Face
Mini Volcano	Classroom teacher-led activity where children created their own volcanos. Followed on from *Science is Spectacular!* show and was prepared by Scitech	00:16			

Table 3.3 outlines the different STEM sessions the case children participated in. It includes the classroom teacher-led *Light Investigation* session which was observed for the purposes of familiarising the children to the data collection process. It was not included in the data analysis. A record of the data collected for each case child has been outlined in Table 3.4.

Table 3.4

Overview of data collected for each case child

	Data Type	Session	Beth	Chloe	Jett
School-based data	Video observation	*Light Investigation* (run by classroom teacher)	Present	Present	Absent
	Video observation	*Science is Spectacular!*	Present	Present	Present
	Video observation	*Mini Volcanos*	Present	Present	Present
	Video observation	*Quiet as a Mouse*	Present	Present	Present
	Video observation	*Bend, Twist, Stretch & Squash*	Absent	Present	Present
	Video observation	*Sound Cups*	Present	Absent	Present
	Video observation	*What's in the Cup?*	Present	Present	Present
	Video observation	*DIY Shakers*	Present	Present	Present
	Audio Interview	After *Light Investigation* lesson	Present	Present	N/A
	Audio Interview	After *Science is Spectacular!*	Present	Present	Present
	Audio Interview	After workshops and *Quiet as a Mouse*	Present	Present	Present
	Audio Interview	With classroom teacher			
	Mapping	Of classroom			
	Field notes	During all sessions			
	Photographs	During all sessions			
Home-based data	Video observation	*Wind Houses*	Present	Present	Present
	Video observation	*Egg Drop*	Present	Present	Present
	Video observation	*Ball Run*	Present	Present	Present
	Video observation	*Floating Boats*	Present	Present	Present
	Audio Interview	After all sessions	Present	Present	Present
	Mapping	Learning environments	Present	Present	Present

Table 3.4 illustrates how numerous data was collected for each case child, including multiple interviews and video observations. Further, mapping of their learning environments, field notes, and photographs were also collected. It shows how Jett was absent from the classroom teacher-led initial session *Light Investigation*, and as such, did not participate in a semi-structured interview following this session. The purpose of the *Light Investigation* session was to develop the children's level of comfort with the research process and was not included in data analysis. Jett was present for all the Scitech sessions, while Chloe and Beth were each absent for one due to illness.

3.9.1 Video observations

A significant portion of the data collected for this study consisted of video observations. This data collection method was chosen for its capacity to capture real-time, durable, and shareable records of multimodal interaction (Jewitt & Mackley, 2019). Utilising video observations allowed for the direct collection of data when children engaged in Scitech's online learning experiences, strengthened by the insights gained from interviews (Merriam & Tisdell, 2015). Several considerations were taken into account when preparing and conducting the video data collection, as follows.

3.9.1.1 Video Conferencing 'Rehearsal'

The importance of clear visibility of facial expressions and speech was recognised as an essential part of collecting video data (Heikkilä & Mannila, 2018). As such, a video conferencing rehearsal took place in the Year 1 classroom a week before the first Scitech session. Participating in the video conferencing rehearsal were the Scitech team, the Year 1 classroom teacher, and the researcher.

During the rehearsal, the Scitech presenters practised all aspects of their delivery through Microsoft Teams. This rehearsal included ensuring that Milly was visible on the AV screen – it was noted here that the windows at the back of the classroom provided too much light, so a note was made to cover them with butcher's paper prior to first session – and that the Internet connection could support the Microsoft Teams meeting. They also used the rehearsal as an opportunity to confirm that they could physically move the cameras from one part of the set to another, zoom in and out, and change the facilitator's background using green screen technology. The classroom teacher tested out where the most suitable to place her laptop was so that its webcam would capture the whole class, finding a shelf underneath the AV screen to be the most suitable spot.

From the researcher's perspective, it was an opportunity to test screen-recording the Microsoft Teams meeting using her laptop in the classroom, as well as to decide where the most suitable to place the Go Pro camera so that all case children would be visible was. This resulted in a small table being positioned underneath the AV screen for the Go Pro camera, and the Year 1 classroom teacher marking her carpet with masking tape to identify the boundaries the children needed to sit within to be captured by the recordings. This decision ensured the video data would record unobstructed vision of the children's faces, body gestures, and speech. It was decided that the researcher would move the Go Pro camera around the classroom as necessary, to capture different moments of the hands-on activities. In doing so, this would assist in offering angles which are different to that captured by the Microsoft Teams screen recording (Flewitt, 2006; Riordan, 2022). Likewise, during the afterschool STEM club sessions, the Go Pro camera was positioned so that it offered a broad view of the rooms in which the children were working, offering a broader perspective of their home environment than the Microsoft Teams screen recording could capture.

3.9.1.2 Process of recording

The period of each video observation was bound by the duration of the Scitech session. Once the Scitech team arrived in the Microsoft Teams meeting, the researcher began screen recording on her laptop using QuickTime Player. As the children settled in the classroom or home, the researcher started recording on the Go Pro camera. As the session ended, and one or more of the participants had signed off the Microsoft Teams meeting, the researcher ended the screen recording and the Go Pro camera recording.

3.9.1.3 Passive Researcher

During the school-based sessions, the researcher remained towards the back of the classroom so as not to draw attention to herself and distract the children. When the hands-on activities were conducted in the classroom, the researcher remained in the classroom with the case children to observe them. It was pre-determined that the Year 1 classroom teacher would move to the wet area to facilitate the hands-on activities with the rest of her class. The case children were instructed by Miss Bird to follow Milly's instructions during these times. There were moments during the hands-on activities when the case children encountered minor fine motor skill challenges, such as difficulties tying knots. In these instances, the researcher was approached, or stepped in, to help the children. Likewise, there were a few instances when the children were particularly loud and unable to hear Milly's instructions. When this occurred, the researcher drew upon her experience as a primary school teacher to evaluate when a classroom teacher might intervene, had they been in the room. She then waited a further 30 – 60 seconds before stepping in, to give Milly time to respond to the situation. Not wanting to interfere with the experience of online delivery, the researcher gave Milly opportunities to implement various classroom management strategies by remaining a passive observer.

During the afterschool STEM club sessions, the researcher remained unobtrusive while filming in the same home environment as the children. For Beth, the Go Pro camera was able to be set-up at the back of the playroom, and the researcher was able to observe the session via her laptop in the living room, as well as from the door to the playroom. In the case of Chloe, the study was smaller, and the researcher stood in the room for most of the session. In the case of Jett, the Go Pro was set-up in the kitchen facing the dining room table. The researcher split her time being in the kitchen and in her car, where her laptop was hot spotted to her phone due to Wi-Fi connectivity issues within the house. The duration and details of the video observations that were conducted are outlined in Table 3.5.

Table 3.5

Overview of video observation data

Delivery	Location	Session	Duration of session	Screen recording	Go Pro
Online delivery	School-based	*Science is Spectacular!*	00:39:00	Yes	Yes
		Quiet as a Mouse	00:44:00	Yes	Yes
		Bend, Twist, Stretch & Squash	01:03:00	Yes	Yes
		Sound Cups	01:00:00	Yes	Yes
		What's in the Cup?	01:10:00	Yes	Yes
		DIY Shakers	00:58:00	Yes	Yes
	Home-based	*Wind Houses*	00:50:00	Yes	Yes
		Egg Drop	00:43:00	Yes	Yes
		Ball Run	00:42:00	Yes	Yes
		Floating Boats – Jett & Beth	00:43:00	Yes	Yes
		Floating Boats – Chloe	00:43:00	Yes	Yes
Face-to-face delivery	School-based	*Light Investigation*	00:41:00	N/A	Yes
		Mini Volcanos	00:16:00	N/A	Yes

Table 3.5 demonstrates how data was collected via both Go Pro and screen recording, and that the sessions lasted an average of 47 minutes. As Chloe had a conflicting afterschool commitment on the date of the final *Floating Boats* session, she participated in a one-on-one session with Tahlia the following day.

3.9.2 Semi-structured interviews

Interviews are purposefully designed to gather information that cannot be directly observed (Brinkmann & Kvale, 2015; Patton, 2015) and offer insight into another person's experience (Patton, 2015). There are many types of interviews which qualitative researchers can employ, including but not limited to: structured, semi-structured, and unstructured (Cohen et al., 2018; Lincoln & Guba, 1985). The key difference between these types of interviews, according to Kvale (1996) lies in their degree of structure. For instance, a structured interview involves a pre-determined sequence and wording of questions, where the interviewer has little freedom to make modifications. By contrast, an unstructured interview is an open situation with far greater flexibility (Cohen et al., 2018). While semi-structured interviews require questions be prepared in advance, they are strategically open-ended, and the wording and sequence can be tailored to each participant. Additionally, the researcher can make use of prompts, follow-up questions or comments to guide the discussion (deMarrais & Lapan, 2003).

The choice of an appropriate type of interview is dependent on the research questions and approach (Flewitt, 2013). For this study, the semi-structured interview method was selected as it has been identified as a useful method for collecting data with children (Prior, 2016). Specifically, it provided flexibility for the researcher to unpack moments of interest that arose for each child, and tailor questions and prompts appropriately (Galletta, 2013). The use of open-ended questions provided children with time and space to describe their views and experiences in their own words (Kortesluoma et al., 2003).

In the context of this study, the primary instrument of data collection was the researcher, who responded to participants' answers, seeking more details or clarification (Glesne & Peshkin, 1992). The researcher adhered to the basic interview principles of rapport building, clear questioning, attentive listening, and using the interviewee's language (Ponizovsky-Bergelson et al., 2019). Firstly, to establish rapport with participants, initial interactions and conversations were conducted with the case children in the classroom, and at home with their parents. Rapport was also developed in the time it took to walk the child from their classroom to the interview room. During this time, the researcher asked questions about how the child's morning was going, queried the fancy dress they were wearing, and asked about their favourite football team. These questions were intended to help the children feel more comfortable before being interviewed. Likewise in the home, the Meet-and-Greet that was conducted prior to the afterschool STEM club sessions allowed the researcher to get to know the parents and answer any questions they had. It was also an opportunity for the children to become used to seeing the researcher in their home prior to filming.

Interviews were audio recorded using the researcher's iPhone Voice Memo app for later transcription. Each audio recording was backed up immediately to the researcher's university R:// drive and external backup drive following the interview, before being deleted from the iPhone. No notes were taken during the interviews, with the researcher's focus remaining completely on what the participant had to say. To assist with stimulating recall, short video compilations of the Scitech sessions were shown to the children during their interviews (Dempsey, 2010).

The semi-structured interviews included planned questions and prompts as well as flexibility to respond to participants' emerging perspectives and ideas (Merriam & Tisdell, 2015; Prior, 2016). Additionally, the researcher occasionally introduced new questions to further explore or confirm what was being said. Different types of questions, including closed-ended, open-ended, and encouragement, were used to solicit varied responses (Ponizovsky-Bergelson et al., 2019). The dates the semi-structured interviews were conducted are outlined in Table 3.6.

Table 3.6

Dates of semi-structured interviews

Interview context	Beth	Chloe	Jett	Classroom teacher	Milly (Scitech)	Tahlia (Scitech)
Post-*Light Investigation* session	31/08/2022	31/08/2022	N/A			
Post-*Science is Spectacular!*	08/09/2022	02/09/2022	02/09/2022			
Post-workshops and *Quiet as a Mouse*	21/09/2022	20/09/2022	20/09/2022	20/09/2022	21/09/2022	
Post-afterschool STEM club	22/11/2022	08/12/2022	24/11/2022			18/11/2022

Table 3.7 outlines the duration of each semi-structured interview.

Table 3.7

Duration of semi-structure interviews (MM: SS)

Interview context	Beth	Chloe	Jett	Classroom teacher	Milly (Scitech)	Tahlia (Scitech)
Post-*Light Investigation* session	11:53	14:26				
Post-*Science is Spectacular!*	09:15	10:22	08:56			
Post-workshops and *Quiet as a Mouse*	11:57	12:48	11:59	52:08	48:18	
Post-afterschool STEM club	36:15 (23:32 – Beth) Remainder w/ parent	44:47 (23:07 – Chloe) Remainder w/ parent	30:33 (14:35 – Jett) Remainder w/ parent			77:22

Table 3.7 shows the duration of each semi-structured interview. The adult interviews took between 15 and 80 minutes, while the children's interviews ranged from 9 – 23 minutes. The educators and Scitech facilitators spoke for an average of 59 minutes, the parents spoke for an average of 17 minutes and the children spoke for an average of 15 minutes.

Before commencing each interview, the researcher explained to the participants the purpose of the interview, the process of the data collection, what would happen with the collected information and how the data would be treated anonymously and confidentially, expected duration, and a reminder that they could skip a question or cease the interview at any time. Each participant verbally provided their consent to begin the recording for the interview. The recording device was positioned and tested prior to each interview, with the children pressing the Record button each time, which further engaged them in the process. Participants were invited to provide any final thoughts in relation to the experience at the end of the interview, following which they were thanked for their participation.

3.9.2.1 Children Interviews

The purpose of conducting interviews with the case children was to obtain first-hand insights into their experiences and perspectives of Scitech's STEM online learning sessions. The interviews focused on the most recent sessions the children had participated in. The primary objectives were to understand what aspects of the sessions they enjoyed, identify any challenges they encountered, and gather their overall feelings about the online delivery. Consistency was maintained by employing the same set of semi-structured interview questions with each child, although there were variations to follow-up questions based on the responses of each child.

The interview questions were framed in familiar language that the children could understand. As Patton (2015) emphasises, using words that make sense to the interviewee is crucial for obtaining high-quality data during the interview process. In accordance with this principle, technical jargon, and complex concepts were avoided when discussing Scitech's online delivery with the children. Language adjustments were made to ensure the questions were accessible and meaningful to the children. For example, Scitech's presence in the classroom was often referred to as Scitech being 'on the TV,' rather than referring to it as 'online learning' or 'connecting to a Microsoft Teams meeting.' This approach mirrored the language the children themselves used.

School-based interviews were conducted with the children at their school in a quiet break-out room located down the hallway from their classroom. These interviews took place during a designated crunch-and-sip time in the morning, chosen by their classroom teacher to minimise disruptions. The home-based interviews occurred with the children and their parents at their homes after school, in a room of their choosing. In each case, this was their living areas. The goal was to create a comfortable environment that would encourage open responses from the children. Additionally, stimulated recall techniques were employed during the children's interviews (Dempsey, 2010). This technique involved playing video recordings of the children participating in the relevant Scitech sessions and discussing specific aspects of their interactions. These compilations were created by the researcher prior to each interview. By revisiting these moments, the children were able to recall their experiences more vividly, while the researcher had the opportunity to seek clarification or delve deeper into moments of interest. For the complete set of semi-structured interview questions used refer to Appendix 20. Sample questions for the children are included in Table 3.8.

Table 3.8

Sample of children's interview questions

Category	Example
Feelings about STEM activity	Can you tell me what you enjoyed about this activity? Was there anything you didn't enjoy?
Experience of online delivery	Was there anything about participating online that you didn't enjoy?

The sample questions in Table 3.8 demonstrate the open-ended nature of the interview, and the opportunities given to children to discuss their personal experiences of Scitech's sessions.

3.9.2.2 Educator Interview

The purpose of the interview with the Year 1 classroom teacher was to gain insight into their experience facilitating the online STEM learning experiences within her classroom, as well as her perspective on each case child's creative engagement with the sessions. The educator interview schedule was more comprehensive than the children's, with the set of questions relating to the preparation and delivery of each session, as well as the engagement and creative behaviours of each case child. The interview with the classroom teacher took place in their classroom after school on a day that suited her. For the complete set of semi-structured interview questions used refer to Appendix 20. Sample educator questions are included in Table 3.9.

Table 3.9

Sample of educator's interview questions

Category	Example
Live Shows	Was there anything about participating online that you enjoyed? Can you see benefits to the online delivery of Scitech's shows?
Face-to-Face vs. Online	What differences did you notice in [child's name] as they participated in the online STEM learning experiences, compared to when you deliver STEM activities in the classroom?

The sample questions in Table 3.9 demonstrate the open-ended nature of the interview, and the opportunities given to the classroom teacher to discuss their personal experiences of Scitech's sessions and their observations of the children's creative involvement.

3.9.2.3 Parent Interviews

The purpose of the interview with each of the case children's parents was to gain insight into their experience facilitating the STEM online learning experiences at home, as well as their perspective on their child's creative engagement with the sessions. The parent interview schedule was more comprehensive than the children's, with the set of questions relating to the preparation of the home sessions, as well as the engagement and creative behaviours of their child. The interviews with the parents occurred during the home-based interview with their child. While all three children lived with two parents, the parent who was present during the majority of the four online sessions was the one who participated in the interview. During the parent interview, the children were given the choice to stay and listen or go and play. The parents interviewed are listed below:

- Beth's mum (attended all four sessions)
- Chloe's dad (attended three and a half of the four sessions)
- Jett's mum (attended three of the four sessions)

For the complete set of semi-structured interview questions used refer to Appendix 20. A sample parent question is included in Table 3.10.

Table 3.10

Sample of parent's interview questions

Category	Example
Experience of the online afterschool STEM club	Did you encounter any challenges with the club being delivered online?

The sample question in Table 3.10 demonstrates the open-ended nature of the interview, and the opportunities given to the parents to discuss their personal experiences of Scitech's sessions.

3.9.2.4 Scitech Interviews

The purpose of the interviews with the Scitech facilitators was to gain insight into their experience preparing and delivering the online STEM learning experiences, as well as their perspective on the children's creative engagement with the sessions. The Scitech interview schedule was more comprehensive than the children's, with the set of questions relating to the preparation and delivery of the sessions as well as the children's creative behaviours. The interviews with the Scitech facilitators took place during their work hours. They remained in their Perth-based office and participated in the interview via Zoom. For the complete set of semi-structured interview questions refer to Appendix 20. A sample Scitech facilitator question is included in Table 3.11.

Table 3.11

Sample of Scitech's interview questions

Category	Example
Experience of the online delivery	How did it feel to deliver the [show/workshop] online, instead of face-to-face?

The sample question in Table 3.11 demonstrates the open-ended nature of the interview, and the opportunity given to the Scitech facilitators to discuss their personal experiences of the online delivery.

3.9.3 Field Notes

Jewitt & Mackley (2019) recommend the use of research field notes in conjunction with video data. These field notes can serve various purposes, such as providing substantive, theoretical, methodological, or personal insights. Throughout the project, the researcher created field notes to document noteworthy occurrences during the preparation and delivery of online sessions, as well as additional notes that could support participants' comments in the future. After each observation and interview, the researcher completed field notes electronically, following the data management plan for the project, which included storing them securely on the researcher's university R:// drive and external back-up drive. While in the field, the researcher utilised the Notes app on her iPhone to create memos.

3.9.4 Mapping of environments (diagrams)

The researcher conducted systematic mapping of the physical environments where the children engaged in Scitech's STEM sessions. The aim of this mapping process was to identify the characteristics, arrangement, and role of digital technologies within each environment, thus providing insights into their influence on online learning experiences. To accomplish this, the researcher captured photographs of the physical environments, which subsequently served as references for creating diagrams using Adobe Photoshop. These diagrams were saved as image files for further analysis and documentation. The specific physical environments that underwent mapping are listed in Table 3.12. The maps are included in Chapter 4.

Table 3.12

List of environments included in mapping

Environment	Child	Room
School	All children	Classroom
Home	Beth	Playroom
Home	Chloe	Dad's study
Home	Jett	Open living area (dining room)

3.10 DATA ANALYSIS

Analysing qualitative data involves moving from raw data to explaining and interpreting the phenomena being investigated where the researcher is the primary instrument (Cohen et al., 2018). Ultimately, a researcher aims to ensure the research questions are answered, as well as contribute additional information which may come to light during the analysis (Merriam & Tisdell, 2015). Given the diverse types of data collected, the analysis for this project was comprehensive, employing specific qualitative analysis methods tailored to each data type. Video observations were analysed iteratively using V-Note Pro, a specialist video analysis software program, with new themes identified as the data was reviewed (Strauss & Corbin, 1990). Findings from the video data were used for narrative analysis to create rich, written descriptions of the children's experiences. The semi-structured interviews underwent a thematic analysis using the cloud-based software, Quirkos. Each of the data analysis methods employed are outlined in depth later in this chapter.

In the instance of case study research, data analysis requires organising all the collected data, such as video observations, interviews, and researcher field notes, into a case study database (Yin, 2014). Having the data organised as such serves as a systematic archive for easy retrieval during the analysis process (Patton, 2015). For this project, a case study database was compiled in accordance with the project's Data Management Plan. Specifically, all data was organised and stored on the researcher's university R:// drive and backed up to a securely stored external hard drive.

In a multiple case study, the analysis consists of within-case analysis (focusing on understanding the variables specific to each case) as well as cross-case analysis (comparing and synthesising findings across cases) (Yin, 2014). In this project, the experiences of the three children were analysed (within-case analysis) before the researcher compared the experiences of the children to one another (cross-case analysis). The *A-E Children's Creativity* framework (Murcia et al., 2020) underpinned the analysis of all data in this study and was presented in Figure 2.2. As discussed in Chapter 2, this is a literature-informed and empirically tested framework that provides structure for assessing in what ways, and to what extent, children engaged creatively during the STEM learning experiences.

3.10.1 Video Observations

The use of video observations provides a valuable means of capturing and analysing real-time interactions and behaviours occurring during the research context. This section focuses on the analysis of video data.

3.10.1.1 Computer Assisted Qualitative Data Analysis Software: V-Note Pro

Computer Assisted Qualitative Data Analysis Software (CAQDAS) offers valuable capabilities when it comes to organising and managing large volumes of data, assisting analysis, and facilitating communication within research teams (Merriam & Tisdell, 2015). It is particularly beneficial when handling large amounts of data due to its features of codes, selective retrieval, and quantitative counts of qualitative data (Cohen et al., 2018). However, the term 'assisted' is crucial, for the software itself simply serves as a tool for organisation and categorisation rather than conducting the actual analysis (Bogdan & Biklen, 2011; Merriam & Tisdell, 2015). Further, CAQDAS is not a specific method or approach to analysis, but rather a supportive tool for researchers to organise their analysis process (Gibbs, 2013). Beyond organisation and categorisation, Kelle and Laurie (1995) assert that CAQDAS contributes to the validity and reliability of qualitative research by managing data and ensuring the trustworthiness of data through comprehensive retrieval. The speed and efficiency of organised and systematic data collection and retrieval are significant advantages, despite the time-consuming data entry process (Bellocchi et al., 2019; Gibbs, 2013).

For this research project, V-Note Pro (https://v-note.org/) was used to assist in the coding and analysis of the video data collected of each Scitech session. V-Note Pro is video analysis software that provided a platform within which to view, label, and extract qualitative statistics from the videos as well as observe and categorise the children's demonstrations of creativity. The video coding process took the form of three coding phases which are outlined below.

3.10.1.2 Coding Phase 1: communication type

The video analysis was based on identifying and examining selected stages of activity, referred to as *episodes*. Episodes are defined as stages of intentional activity within a learning experience, when thinking and learning is evidenced, as defined by the researcher. Selected episodes or parts of episodes, form the basis for units of analysis (Hackling et al., 2014; Heikkilä & Mannila, 2018).

After compressing, labelling, and importing the video data into V-Note Pro, the first phase of the analysis process was to identify the episodes. This was achieved through the first layer of coding, Phase 1: communication types. The video data totalling almost nine hours was broken down into 1,053 episodes, in which episodes were clearly bound time periods defined by the type of communication that was occurring between the participants on screen. These types of communication were defined as being either:

- *Dialogic (two-way):* communication was occurring in direct back-and-forth between the Scitech facilitator and the children.
- *Children-only*: Children were directed to talk amongst themselves in the classroom.
- *Adult-Adult:* Scitech and the teacher/parent were communicating directly to one another.
- *Scitech-only:* Scitech facilitators were talking directly to the children in the form of demonstrations or instructions.

- *No communication to others on screen*: Children engaged with a task in front of them, may have communicated with another person physically in the same room.

These communication types were identified inductively by viewing the data.

3.10.1.3 Coding Phase 2: evidence of creative moments

Analysis was conducted on the 1,053 episodes to identify which ones qualified as having evidence of children's creativity according to the *A-E of Children's Creativity* framework criterion of product. This term was re-worded for this study to *creative moments*, as it better encompassed the nature of the product types of the children created. Two distinct categories of creative moments were identified, each with two sub-categories:

- *Materials-based* > *making:* instances where the children were constructing something with their hands.
- *Materials-based* > *experimenting*: instances where the children were participating in hands-on experiments.
- *Ideas-based* > *predicting:* instances where the children were making predictions before an experiment occurred.
- *Ideas-based* > *problem-solving:* instances where the children shared solutions to problems that arose during shows, workshops or afterschool STEM club.

In total, 696 episodes with evidence of creative moments were identified. This coding arose from a combination of inductive and deductive coding. Initially, the researcher reviewed the data deductively for episodes which met the criteria of having instances of a creative product. Then, an inductive process was undertaken to determine the nature of those creative moments. This led to the categorisation of the four types of creative moments: materials-based (making, experimenting)*;* and ideas-based (predicting, problem-solving). It became evident that in some episodes, more than one type of creative moment could be applied. For instance, while children were constructing their boats (materials-based > making), they would frequently experiment to see if the boat could float (materials-based > experimenting). As such, episodes were coded according to which creative moments were evident, meaning there were some episodes with more than one creative moment label applied.

3.10.1.4 Coding Phase 3: focus strategies

Following the identification of the episodes with evidence of creative moments, the next phase of coding involved identifying which types of focus strategies were employed by the Scitech facilitators during those episodes. The purpose of this coding was to ascertain what enabling communication elements encouraged children's creativity, as well as the ways the facilitators fostered a positive socio-emotional climate. These are two elements of place identified in the *A-E of Children's Creativity* framework. The focus strategies emerged from inductive coding by viewing the video data and observing the types of strategies employed by the Scitech facilitators. The focus strategies identified were labelled into the following categories:

- *Extrinsic motivators:* Milly/Tahlia providing motivators, such as time limits.
- *Questioning (predicting, explaining):* Milly/Tahlia posing questions to the children.
- *Responding to children's queries and comments:* Milly/Tahlia responding to child-initiated questions or comments.
- *Show me*: Milly/Tahlia asking the children to share their progress with a task.
- *Showing and sharing:* Milly/Tahlia sharing their own progress with a task.
- *Silence (time to focus)*: Milly/Tahlia strategically giving children quiet time to work.
- *Task setting (directions, extension):* Milly/Tahlia providing instructions.

3.10.1.5 V-Note Pro statistics

Following the completion of the coding process within V-Note Pro, the researcher made use of V-Note Pro's statistics features, specifically the *Export Linear Table* feature. This provided a breakdown of how many instances each code occurred within the data, including duration and percentage of the video. These findings have been included in Chapter 4. A screenshot of V-Note Pro is presented in Figure 3.1.

Figure 3.1

Screenshot of V-Note Pro analysis

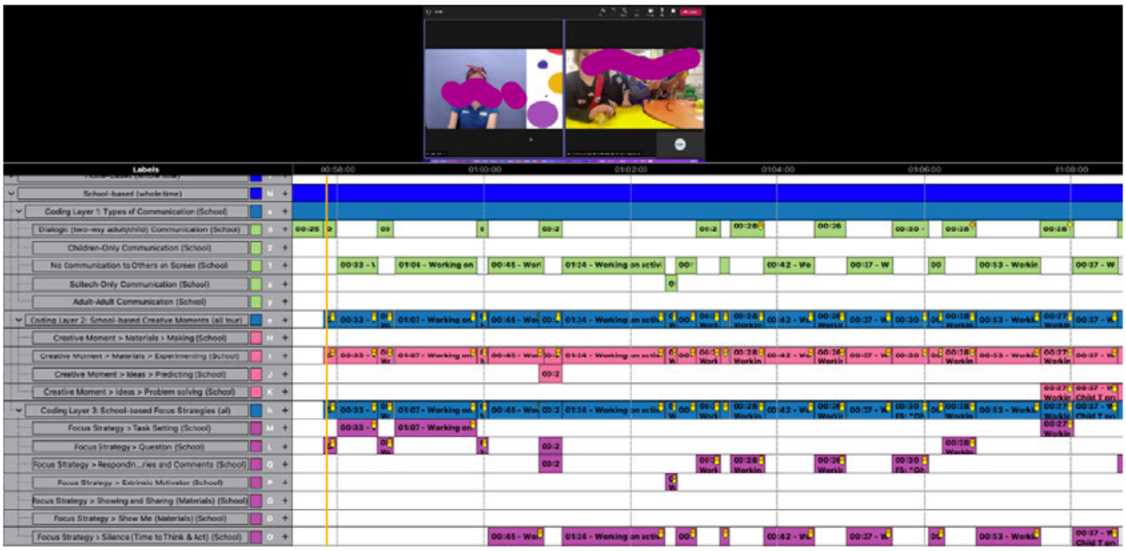


Figure 3.1 shows a screenshot of the researcher's V-Note Pro file after they had finished their three-phase coding process. At the top of the screen is the video itself, a screen recording of Milly and the children participating in a hands-on activity. Underneath are the different labels (codes) that the researcher applied to the video data.

3.10.2 Narrative analysis

Following the coding and review of video data in V-Note Pro, the researcher began to construct a narrative analysis of each Scitech session. Narrative analysis is a common approach within case study research, often enabling readers to connect their own experiences with those reported within the case study (Cohen et al., 2018). Specifically, it is a way of organising the analysed data by constructing a narrative in the form of a series of written descriptions based on the research findings (Cohen et al., 2018). For this study, a series of descriptions was written by the researcher to describe the creative moments observed during each of the sessions. This approach has been used by other early childhood education researchers exploring creativity within STEM (Murcia & Oblak, 2022; Murcia et al., 2020; Tippett & Yanez Gonzalez, 2022), highlighting its suitability for this study.

Twenty-three narrative analysis descriptions were created. The structure of each narrative analysis was consistent, incorporating:

- *Title:* name of the Scitech session being described.
- *Introduction:* a brief description of the Scitech session.
- *Photograph:* a photograph that captures events described within narrative.
- *Narrative:* a written description of what occurred, synthesised from researcher observations and semi-structured interview responses.
- *Place elements:* a table listing which place elements from the *A-E of Children's Creativity* framework and communication types from the V-Note Pro coding were observed.
- *Process characteristics:* a table listing which process elements from the *A-E of Children's Creativity* framework and Creative moments from the V-Note Pro coding were observed.

3.10.3 Semi-structured interviews

The following section provides details about the technology used for the analysis of the semi-structured interviews, as well as the process for thematic analysis.

3.10.3.1 Technology used for analysis of semi-structured interviews

Otter.ai (https://otter.ai/): The researcher utilised the secure online transcription service, Otter.ai to transcribe each audio recording in its entirety. Each transcription was then carefully reviewed and corrected by the researcher for accuracy. Otter.ai is an online service capable of providing transcription for uploaded audio files, ensuring efficient and reliable transcription. The user retains control over the stored data, with the ability to withdraw information at any time. In accordance with Otter.ai's privacy policy, the platform takes comprehensive measures, including physical, administrative, and technical safeguards, to protect the confidentiality, integrity, and availability of personal information. The researcher opted for the paid version of Otter.ai, utilising it for a period of three months. Once the transcription process was completed, the researcher deleted all audio recording and transcription files from Otter.ai, storing them securely on the researcher's university R:// drive and external back-up drive as per the study's Data Management Plan.

Quirkos (https://www.quirkos.com/index.html): The transcriptions developed in Otter.ai were imported into Quirkos, an online tool that facilitated the visual organisation of the data into codes. Initially, the researcher used Microsoft Excel (https://www.microsoft.com/en-au/microsoft-365/excel) for this process, but found Quirkos offered greater visuals and flexibility. In accordance with Quirkos' privacy policy, the platform takes comprehensive measures, including physical, administrative, and technical safeguards, to protect the confidentiality, integrity, and availability of personal information. The researcher opted for the paid version of Quirkos, utilising it for a period of twelve months. Direct quotes from the interviews were visually placed within bubbles on the screen for review and analysis. This allowed the researcher to organise data from across multiple interviews into themes.

3.10.3.2 Thematic Analysis of semi-structured interviews

Thematic analysis was chosen as the analytical method to identify themes in the interview data (Braun et al., 2019; Cohen et al., 2018). Following this approach, themes were developed through exploring and developing an understanding of the patterns within the data, following Braun et al.'s (2019) six phases of reflexive thematic analysis.

Phase one - Familiarisation: The first phase involved the researcher becoming 'immersed' in the data and making casual notes (Braun et al., 2019). For this study, the researcher became familiar with the semi-structured interview data during the Otter.ai transcription process, which involved listening to each interview several times. Casual notes were made at the time of listening and re-reading the transcriptions.

Phase two - Generating codes: The next phase of the process saw the researcher succinctly and systematically identifying meaning through the data, organising it around similar meanings in the form of 'chunks' of text (Braun et al., 2019). For this study, the researcher created initial codes inductively within Quirkos, whereby the starting point of analysis was with the data rather than existing concepts or theories (Terry et al., 2017).

Phase three - Constructing themes: Themes were then constructed and tested out in relation to the research questions and overall data (Braun et al., 2019). This involved reviewing codes and collating similar codes together. This process was easily completed in Quirkos, which allowed for the merging of 'quirks' (chunks of text from interviews) when codes were to be combined, and the re-naming of quirks as theme names changed.

Phase four and five - Revising and defining themes: During these phases, clear definitions of each theme were developed, helping to clarify the scope of each theme as well as development of thematic maps (Braun et al., 2019). The maps assisted in seeing how themes fitted together and ensured themes did not overlap. Rigorous testing continued to be carried out of the themes, to ensure they related to the research questions and overall data.

Phase six - Producing the report: The final phase involved revisiting the research questions, notes from earlier phases, lists of codes, and theme definitions to ensure the final themes remain close to the data and answer the research questions (Braun et al., 2019). The researcher completed this process, resulting in the final themes presented in Chapter 4.

The themes generated through this process are organised under three categories, chosen by the researcher: *experiences, affordances,* and *challenges.* These categories assist in the logical organisation of the themes that emerged. A screenshot of Quirkos presented in Figure 3.2 demonstrates how it was used for the thematic analysis of this study's semi-structured interview data.

Figure 3.2

Screenshot of Quirkos

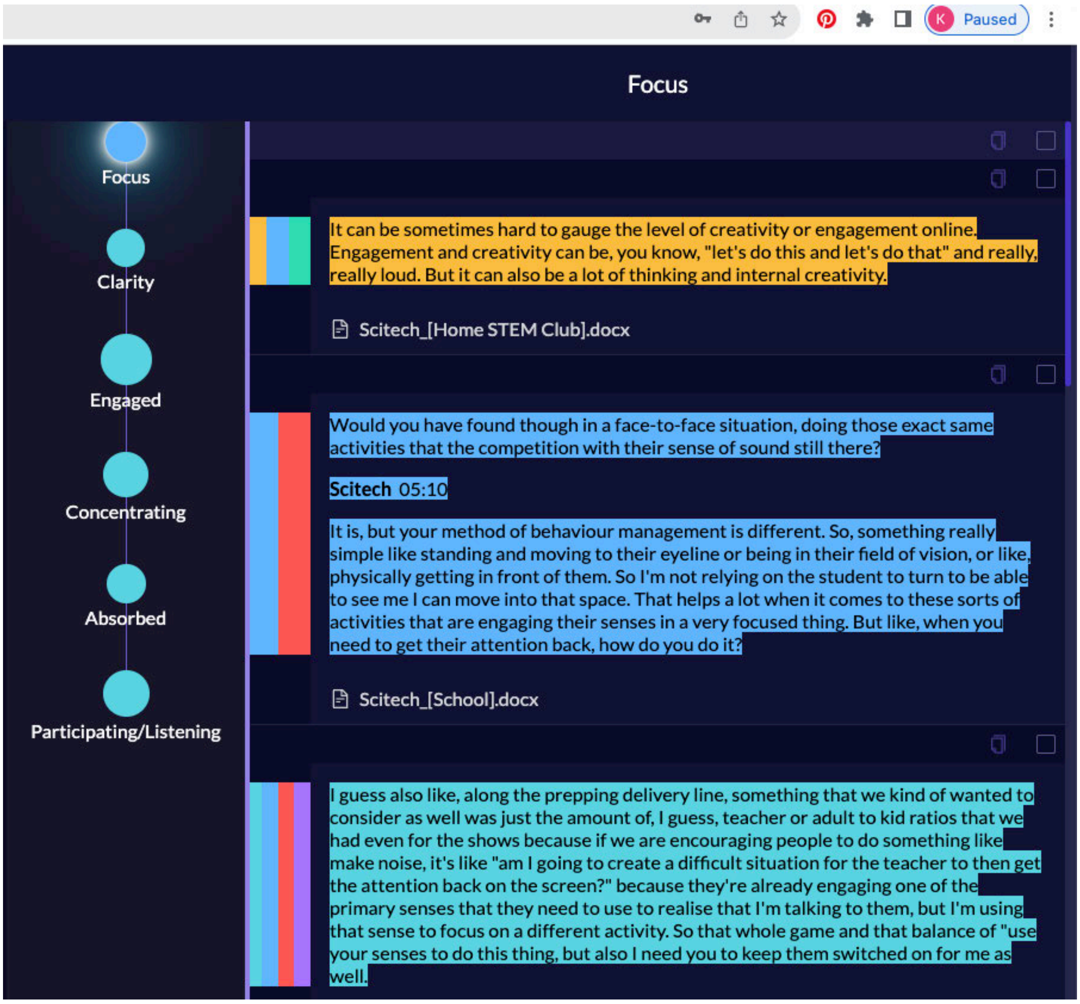


Figure 3.3 captures the way Quirkos allowed for themes to be created, and extracts from each of the semi-structured interviews be grouped within these themes. Specifically, this screenshot captures the theme of focus which is detailed in Chapter 4 and Chapter 5 of this thesis.

3.10.4 Field notes

In this research, field notes played an important role in facilitating the qualitative analysis of the collected data, complementing the coding process. The researcher revisited the field notes to identify key emerging themes and searched for supporting or related material once themes had been identified through coding. Any relevant field notes taken during the interviews were integrated into the narrative descriptions of analysis. Field notes were documented in dot point format before, during, and after each Scitech session in the researcher's iPhone Notes app.

3.10.5 Mapping (diagrams)

In conjunction with the coding process, the utilisation of maps proved instrumental in facilitating the effective qualitative analysis of the collected data. These were created by the researcher using Adobe Photoshop, drawing upon photographs of the environments taken during the sessions. The maps were examined to provide additional insight into the influence the children's physical environments had on their online learning experiences. For instance, the maps allowed the researcher to cross examine the similarities and differences of each child's home learning environments during the afterschool STEM club sessions.

3.11 MEASURES OF RESEARCH QUALITY

It is acknowledged that every research project faces threats to validity and reliability, and these threats can never be completely erased (Cohen et al., 2018). The following section explores the methods employed in this project to establish research quality.

It is essential for researchers to ensure their instruments for understanding phenomena are as sound as possible, particularly when observing unclear constructs such as 'creativity' (Cohen et al., 2018). In qualitative research, validity concerns the extent an instrument measures what it claims to measure, along with ensuring the meaning and interpretation of results are sound (Cohen et al., 2018). Reliability, meanwhile, is concerned with precision, accuracy, and replicability (Cohen et al., 2018). Lincoln and Guba (1985) posit the term 'reliability' be replaced with the notion of 'dependability' as it is more suitable for qualitative research. There are several ways in which a researcher can ensure validity, dependability, and transferability in a qualitative research project, including triangulation, adequate engagement in data collection, researcher's reflexivity, and audit trails. These strategies are explored in the context of this research project in the sub-sections below.

3.11.1 Triangulation

Triangulation is one of the best-known strategies to ensure the internal validity of a study (Merriam & Tisdell, 2015). As Patton (2015) explains, “triangulation, in whatever form, increases credibility and quality by countering the concern (or accusation) that a study’s findings are simply an artifact of a single method, a single source, or a single investigator’s blinders” (p. 674). This study employed triangulation using multiple sources of data, comparing and cross-checking data collected through observations at different times, and interview data collected from people with different perspectives or from follow-up interviews with the same people. This approach is a powerful strategy for increasing the credibility of research (Merriam & Tisdell, 2015).

3.11.2 Adequate engagement in data collection

Another strategy for establishing credibility is through adequate engagement in data collection. This relates the notion of the data and emerging findings feeling *saturated*, in other words, the researcher begins to see or hear the same observations or themes over and over, with no new information surfacing as more data is collected (Merriam & Tisdell, 2015). This study had a fixed number of Scitech sessions that were observed, and a pre-determined number of interviews. However, through the process the researcher observed adequate engagement and saturation in several ways. For instance, in observing how children demonstrated creativity online, the researcher consistently observed the same processes in the children during each of the sessions. Likewise, during the interviews with the children, there was consistency in their responses about how they enjoyed the online delivery. By the end of the data collection process, the researcher was confident the data had reached a satisfactory saturation point.

3.11.3 Researcher’s position or reflexivity

Reflexivity is an essential component of qualitative research (Berger, 2015). Reflexivity acknowledges that the researcher is an inescapable part of the social world they are researching (Atkinson, 2006; Hammersley & Atkinson, 1983) and they bring their own values to the research situation. Hammersley and Atkinson (1983) further emphasise that qualitative data analysis itself becomes a constructed interpretation, where reflexivity influences decision around organisation, theme selection, and narrative style. Researchers need to explain their biases, dispositions, and assumptions regarding the research to be undertaken. Further, Patton (2015) argues that credibility hinges partially on the integrity of the researcher, and one approach to dealing with this issue is for the researcher to:

> Look for data that supports alternative explanations...failure to find strong supporting evidence for alternative ways of presenting the data or contrary explanations helps increase confidence in the initial, principal explanation you generated (p. 653-654).

The researcher stated their motivation for research in Chapter 1 of this thesis. They described their pre-existing interest and experience as a STEM educator and advocate for effective online learning. This position had the potential to affect the study in that a positive disposition could make the researcher hesitant to observe constraints, challenges, or limitations. This risk was mitigated by the inclusion of probing questions in the semi-structured interview schedule for all participants, prompting them to reflect on challenges or aspects of the online delivery they did not enjoy. This led to the emergence of a category titled, *challenges* in the thematic analysis of the semi-structured interview data.

The researcher maintained a professional relationship with all participants throughout the study. A positive rapport was quickly established with the parents, Scitech facilitators, and the classroom teacher, and the researcher was aware of the trust and responsibility placed upon them. Building relationships with the children was crucial in understanding their experiences of creativity during online STEM learning activities. Care was taken to adhere to best practice throughout the entire research process. Additionally, this study drew on multiple data sources which facilitated data triangulation and helped mitigate researcher bias.

3.11.4 Audit trail

An audit trail in qualitative research describes in detail the ways the data was collected, how categories were derived, and how decisions were made throughout the research process. Part of this process involves the researcher keeping field notes on the processes throughout the project (Merriam & Tisdell, 2015). This is to account for the notion that "while we cannot expect others to replicate our account, the best we can do is explain how we arrived at our results” (Dey, 1993, p. 251). Throughout this study, the researcher maintained field notes during the process of data collection and data analysis. The process for collecting and analysing the data has been outlined in detail in this chapter, along with the supporting appendices.

3.11.5 Transferability

By design, qualitative research does not aim for replicability, but rather transferability, where the researcher needs to provide “sufficient descriptive data” to make transferability possible (Lincoln & Guba, 1985, p. 298). To ensure the possibility of transferability, researchers can create “thick description of the sending context so that someone in a potential receiving context may assess the similarity between them and…the study” (Lincoln & Guba, 1985, p. 125). These rich descriptions include details of the findings with adequate evidence presented in the form of quotes from participant interviews, field notes, and artefacts (Merriam & Tisdell, 2015). Included in Chapter 4 of this thesis are rich descriptions in the form of photographs and narrative analysis. The children’s experiences of participating in the online Scitech sessions are described in detail, drawing upon researcher observations, and supporting data from participant interviews. These details established the context and experiences of the children and with the notion that qualitative research seeks to represent the phenomenon being investigated in a full and fair way, as opposed to seeking to generalise (Cohen et al., 2018).

3.12 ETHICAL CONSIDERATIONS

Ethics has been defined as “a matter of principled sensitivity to the rights of others” (Cavan, 1977, p. 810). In education research, it is crucial for researchers to consider the impact of their studies on participants and uphold their dignity as human beings (Cohen et al., 2018). This project adhered to the *NHMRC National Statement on Ethical Conduct in Research Involving Humans (2018)* and followed the ethical regulations set by Curtin University. Ethical approval for the research was obtained through Curtin University’s Human Research Ethics Approval process and Catholic Education Western Australia’s approval process. Copies of the approval letters can be found in Appendix 1 and Appendix 2. This research was categorised as a ‘low risk’ study. The following sections provide further insights into the ethical considerations for this research project.

3.12.1 Informed consent

The principle of informed consent is underpinned by the concept of autonomy, recognising an individual's right to freedom, and self-determination (Cohen et al., 2018). Participants must have the ability to assess the risks and benefits associated with their participation in research and make an informed decision on whether to take part or withdraw (Frankfort-Nachmias & Nachmias, 1992; Howe & Moses, 1999). Informed consent is an ethical and legal requirement of research and is a voluntary agreement to participate in the research (Cohen & Morrison, 2000). Informed consent implies all participants understand what will happen throughout the project, as well as their rights and responsibilities. It also states that participates volunteer willingly and can withdraw at any time with no negative consequences.

In the context of this research project, informed consent was obtained from all participants in accordance with legal and ethical requirements. Along with an initial letter of introduction and invitation, participants received a *Participant Information Form* and *Consent Form*. These documents included information outlining the purpose and aims of the study, as well as details of their involvement. Consent forms were returned to the researcher prior to the commencement of data collection. Parents provided consent for their children's participation, and the children themselves demonstrated their willingness by signing their names and colouring in a thumbs-up icon.

To ensure the safety and comfort of the children throughout the study, ongoing consent was sought. At the beginning of each interview, the rights of the child were reiterated, acknowledging their right to participate, skip questions, or withdraw from the interview entirely. Children acknowledged verbally that they understood this before the interview commenced.

3.12.2 Anonymity

Confidentiality of participant identities is crucial, and any potential revelations should only occur with the agreement of the participants, as emphasised by Frankfort-Nachmias and Nachmias (1992). Anonymity essentially means that the information provided by participants should not reveal their identity, and personal data that could uniquely identify individuals should be avoided. When a researcher or another person cannot identify the participant based on the information provided, the participant is considered anonymous (Cohen et al., 2018).

In the context of this study, pseudonyms were used in place of participants' real names and the name and location of the school was not disclosed (Frankfort-Nachmias & Nachmias, 1992). All transcripts and other instances where participants names were recorded were de-identified. The researcher had access to a 'key' for the pseudonyms and this was stored separately from the data. Where possible, photos taken throughout the observation period did not include children's faces, to protect their identities. Where faces were visible in photographs or stills from the video data, measures were taken to obscure their faces, so they were not recognisable.

Due to the uniqueness of the organisation within a Western Australian context, along with the permission received, Scitech have been referred to by name throughout this thesis. While the names of the Scitech staff have been replaced, the organisation name itself has been used. The structure of the project was such that the participating children worked together in the classroom with Scitech and at home with Scitech. As such, it wasn't feasible to protect participant identities from one another.

Non-traceability is an important consideration (Raffe et al., 1989), and all attempts were made to ensure data cannot be combined and individuals identified. For instance, the exact location of the primary school is not revealed in publications, however, it could be possible for interested parties to deduce the location of the school based on the location of the researcher.

3.12.3 Confidentiality

Preserving a participant's right to privacy can be achieved by ensuring confidentiality, which involves not disclosing information which could identify or enable traceability. Measures include avoiding discussions about the individual with others and refraining from sharing information that could reveal their identity in any form (Cohen et al., 2018).

The researcher established their position on confidentiality during the initial recruitment and data collection phases. During these phases, the researcher explicitly communicated to the participants the importance and boundaries of confidentiality as it related to the project. Participants were provided with clear explanations, both written and verbal, regarding the extent of confidentiality. The researcher did not disclose the names of participants to others during, or after, the study verbally or in publications.

3.12.4 Researching with children

Considerations were made regarding the nature of this research, which primarily involved working with children. Specifically, efforts were made to ensure that the research did not interfere with children's learning or adversely impact their after-school time. Data collection for the school-based activities took place during regular school hours and was integrated into the classroom during their usual Investigation Time, resulting in minimal disruption to the children's learning schedule.

The interviews with the children at the school were scheduled during their morning crunch-and-sip times, as per the classroom teacher's request. This timing was chosen to minimise disruption to the children's break times or lesson time. The afterschool STEM club sessions and interviews were conducted immediately after school, from 3:15 – 4:00pm. This time slot was preferred by each of the parents as it allowed for a seamless continuation of the children's engagement in learning activities, while still providing them with time together in the afternoon for dinner, homework, and other activities.

3.12.5 Power imbalance

During the data collection process, the researcher was aware of the potential power imbalance between themselves and the participants (Creswell & Creswell, 2018). It was recognised that the researcher often holds a position of greater power than participants, whether it be due to status, knowledge, role or other factors. This is in part because the researcher determines various aspects of the research, such as agenda, timing, duration and what is considered acceptable and useful data (Cohen et al., 2018).

When working with children, these power imbalances become more pronounced as children are typically more vulnerable and hold less power than adults or researchers. To address these imbalances and create a positive and enjoyable experience for the children, several strategies were employed to establish rapport, build trust, and minimise the power dynamics (Cohen et al., 2018). Throughout the data collection phases, every effort was made to create a safe and comfortable environment. For instance, the researcher took steps to familiarise the children with their presence in the classroom, conducting an initial Meet-and-Greet session prior to the first observation. The novelty of having someone in the classroom quickly dissipated after the classroom teacher-led *Light Investigation* session. Participants were informed that their participation was voluntary, and no pressure was exerted on anyone to continue their participation. The *Participant Information Forms* explicitly stated that participation was a personal choice, and participants had the right to withdraw at any time.

During the interviews, the researcher actively listened to ensure each participant felt heard. The children were engaged in the interview process, with the researcher asking if they were familiar with audio recording on an iPhone. The researcher gave the children the responsibility of hitting the ‘Record’ button and to say whatever they liked into the phone as a sound rehearsal. The children enjoyed listening to the playback, before hitting the ‘Record’ button again to start the interview, and then at the end to stop the interview recording. Involving the children in this process was an attempt by the researcher to help the children feel relaxed, and at least partly in control of the interview process.

3.12.6 Risks to participants

Hammersley and Traianou (2012) outline various types of potential harm that participants could face during a research project, including physical injury, psychological or emotional damage, material loss, reputational harm, and damage to ongoing projects. In the context of this research project, there were no apparent risks or harm for participants. The data collection, including video observations and semi-structured interviews, took place within the normal class time at school and in the participants’ homes after school, ensuring minimal disruption. Any concerns or queries raised by parents, educators or Scitech facilitators were addressed before or during the interviews or sessions. While there was a slight possibility of participants experiencing some form of anxiety due to being closely observed, no participant expressed such concerns. In anticipation of any potential anxiety, measures were prepared by the researcher to ensure participants, especially children, were made aware of their agency and option to withdraw at any time. In the event of unease within the classroom environment the researcher would create distance and potentially postpone observations. Further, ample opportunities were provided for participants to ask questions and seek clarification. It is important to note that the none of the above measures needed to be implemented as participants did not raise any issues to express unease during the data collection phase.

3.12.7 Online interviews

Due to the researcher living in regional Western Australia and the Scitech facilitators residing in Perth, it was necessary for their interviews to be conducted online. The researcher was aware of considerations when using technology for this process. Firstly, not all individuals have access to technological tools; technology is prone to malfunctions and breakdowns; and there is always a risk of compromising confidentiality when employing computer-mediated communication (Merriam & Tisdell, 2015).

In the specific context of this study, interviews were conducted with Scitech facilitators during their work hours, utilising their work devices. Prior interactions with the participants demonstrated that they were familiar with the online video conferencing technology being employed. Precautions were taken to test the audio functionality before commencing the interviews. Additionally, as a back-up measure, audio recording from the researcher's iPhone was taken, with the iPhone placed near the computer to capture the audio. Both computers used for the interviews were connected to secure networks, minimising the potential risk to privacy during the interview sessions.

3.13 LIMITATIONS OF RESEARCH METHOD

Qualitative research can be both time consuming and labour intensive. This study adopted a qualitative, multiple case study approach with several data sources collected. While this approach assisted in providing rich insight into the children's experiences from various perspectives, it was not without its limitations.

Case studies provide detailed insights, focusing on a smaller number of individuals compared to quantitative data (Ward & Delamont, 2020). However, small case studies may not be replicable, representative, or generalisable (Cohen et al., 2018). In this study, a limitation of this research method was the small number of case children involved. As mentioned earlier in the chapter, initially five children volunteered for the study, but due to the unforeseen circumstances previously outlined, only three children were included for data analysis. This limited the ability to draw broader conclusions about the implementation of STEM learning experiences that foster creativity online. It did, however, provide a rich insight into the case children's experiences that offer opportunities for transferability.

According to Merriam and Tisdell (2015), it is advisable to plan data collection sessions based on insights gained from previous observations. A limitation of this study was the absence of follow-up interviews conducted well after the completion of the Scitech activities, which concluded in Term 4, 2022. Additional follow-up interviews could have allowed for exploration of emerging themes that were being identified during the V-Note Pro data analysis phase, that were not initially anticipated during the semi-structured interviews.

The participants who willingly volunteered to be part of this project acknowledged a pre-existing interest in Scitech, science, and STEM. Consequently, their prior engagement in Scitech, science or STEM activities may have contributed to heightened creative thinking skills. However, given the specific, time-bound experiences of the Scitech sessions, this study's focus allowed for a personalised understanding of each child's creative process. This contributes to our understanding of how children's creativity can be fostered online, regardless of the level of creative skills prior to the sessions.

3.14 CHAPTER SUMMARY

This chapter has provided a detailed overview of the research methods adopted for this study. It began by providing details about the research design, including the guiding paradigm, epistemology, and methodological approach before discussing the context for the research. This is important given the extent to which they guide the research approach and determine how findings are interpreted and analysed. This was followed by information about the recruitment of participants, as well as an overview of the data collection and analysis process. The chapter concluded by discussing measures of research quality, ethical considerations, and limitations of the research approach. The research methods were selected because of their suitability to collect findings that answer the underpinning research questions of this study. A qualitative, multiple case study approach allowed for a rich exploration into the children's participation in Scitech's STEM activities, supported by the collection of data from multiple sources. Specifically, this allowed for the unique experiences and perspectives of each child to be highlighted and cross examined. The following chapter outlines the findings from the data collection.

CHAPTER 4: FINDINGS

4.1 INTRODUCTION

The previous chapter provided an overview of the research methods adopted for this study. It justified the choice of a qualitative case study approach to capture children's unique experiences as this aligned with the guiding research questions. This chapter outlines the findings from the data collection, guided by the study's research questions around the environmental elements and creative processes of children. The findings begin with an overview of the case children's experiences during each of the Scitech sessions to provide context. This is followed by diagrams of the children's physical learning environments, as well as a breakdown of the frequency of communication types, creative moments, and focus strategies drawn from the V-Note Pro coding. Then, detailed narrative analysis of the Scitech sessions and thematic analysis of the semi-structured interviews is provided. Finally, key findings from cross-case analysis of the children's experiences are outlined.

4.2 OVERVIEW OF CHILDREN'S EXPERIENCES DURING SCHOOL SESSIONS AND AFTERSCHOOL STEM CLUB

Table 4.1 provides a description of each child's experience as they participated in Scitech's school-based sessions and afterschool STEM club. These descriptions have been written as a synthesis of observations by the researcher and responses from all participants during the semi-structured interviews.

Table 4.1

Overview of children's experiences during school sessions and afterschool STEM club

	Beth	**Chloe**	**Jett**
Science is Spectacular! Science show (school)	Very engaged, she particularly enjoyed the dried ice experiments. Enjoyed the opportunity to make predictions but wanted more time to consider those predictions.	Very engaged, she particularly enjoyed the fire demonstrations. Enjoyed the opportunity to make predictions but wanted less time to do so, as she wanted to keep watching and see what would happen.	Very engaged, he particularly enjoyed the explosions. Enjoyed the opportunity to make predictions, felt he had the right amount of time to make his predictions.
Mini Volcanos Face-to-face (school)	Very engaged and enjoyed activity. Successfully created a mini volcano with her group.	Very engaged and enjoyed activity. Successfully created a mini volcano with her group.	Very engaged and enjoyed activity. Successfully created a mini volcano with his group.

Bend, Twist, Stretch & Squash Workshop (school)	Absent	On task and worked independently and systematically through the materials. Took her time experimenting with some materials, putting down her pencil so she could manipulate with both hands. Didn't quite finish activity. Enjoyed making the slime and followed all instructions.	On task and worked mainly independently. Remained focused for duration of activity. Worked systematically through materials and was the first to finish. Began thinking about extension question but seemed more interested in manipulating the materials. Enjoyed making the slime, followed all instructions. Enjoyed experimenting by adding extra water/powder.
Sound Cups Workshop (school)	Worked quietly and independently on first activity, and independently experimented with different ways to make sounds with her cup. Followed her peers when they got off task, but re-focused with Milly's focus strategy (*show me*). Although she didn't speak during the activity, she chose to come up to the AV screen to smile and wave at Milly. Beth and Jett worked together on telephone activity. Quickly worked out to pull the cups tight to make telephone work.	Absent	Had initial challenges building the sound cup (fine motor skills). Independently experimented with different ways to make sounds with his cup, which were quite unique compared to his peers. Became unfocused half-way through the activity, however re-focused with Milly's focus strategy (*show me*). Beth and Jett worked together on telephone activity. Quickly worked out to pull the cups tight to make telephone work.
What's in the Cup? Workshop (school)	Worked quietly and independently, focused on listening carefully to each of the sounds. Worked slower than the other two children, and it was not clear if she finished activity. Did not appear to participate when Milly asked class to share what they thought the answers were.	Enjoyed sharing with Milly what she thought was in the cups while she worked. Worked mainly quietly and independently and finished investigation. Did not appear to get many answers correct when Milly shared answers with the class and seemed a little disappointed by this.	Enjoyed sharing with Milly what he thought was in the cups while he worked. Worked mainly quietly and independently. Was the first to finish investigation. Appeared to get a couple answers correct when Milly shared answers the class.
DIY Shakers Workshop (school)	Worked quietly and independently on her DIY shaker during both design and making phases. Needed some help with fine motor skill tasks. She designed her shaker like a bunny, scrunching up the pipe cleaner as a tail. While testing her shaker at the end of session, one end fell off and her rice spilt on floor. She was able to quickly fix the shaker.	Worked quietly and independently on her DIY shaker during both design and making phases. Needed some help with fine motor skill tasks. Chose to put both rice and pasta in her shaker, even though the brief was to select just one. Chose to stick a pipe cleaner out the top of shaker to help her identify it as hers.	Appeared excited but a little restless during DIY shaker design phase. Enjoyed sharing with Milly his design idea. Worked quickly on shaker creation, needed some fine motor skill assistance. Finished after only a few minutes. Milly engaged him in several extension questions for remainder of activity. At times he appeared to rush through these activities but said he enjoyed them.
Quiet as a Mouse Puppet show (school)	Enjoyed the show and was emotionally invested in the characters and their journey, particularly enjoyed the character of Melody the cat.	Enjoyed the show, and particularly enjoyed the character of Melody the cat. During the musical instrument investigation, started off with only one	Enjoyed the show, particularly when they were allowed to use their shakers. During the musical instrument investigation, started off with only one

	During the musical instrument investigation, started off with only one instrument between five and the children quickly got off-task. They re-focused once teachers distributed more instruments.	instrument between five and the children quickly got off-task. They re-focused once teachers distributed more instruments.	instrument between five and the children quickly got off-task. They re-focused once teachers distributed more instruments.
Wind Houses Afterschool STEM club (home)	While initially quiet, she quickly began talking enthusiastically, sharing, and engaging in conversation, particularly with the other children. However, she became quieter as the session progressed, appeared focused on her construction. Towards the end of the session, she did not engage in the various conversations. Her house was large and quite elaborate. Her mum sat with her for half the session, providing some assistance towards the end. She lacked confidence in the success of her design during construction phase and did not feel ready to test at the end. Was visibly happy when she and her mum tested the house, and it didn't fall over. Continued working on build after session ended.	Listened and was focused on Tahlia's introduction. Was excited to be online and engaged with task. Engaged regularly in conversations with others, both children and Tahlia. Responded well to Tahlia's focus strategy (*questioning*) regarding her house design. Her parents sat with her and provided some assistance and feedback. Built a detailed house, with consideration to aesthetics as well as structure. Did not appear to finish house design (i.e., no roof, half walls). Engaged with Tahlia's focus strategy *(Showing & sharing)* and was the only child eager to test her house after watching Tahlia test her house. Testing with the hairdryer caused some parts of house to fall. Continued working on build after session.	Listened and focused on Tahlia's introduction. Was excited to be online, particularly opening the pack of materials. Engaged regularly in conversations with others, particularly the other children. Mentioned on several occasions he was finding the build challenging and re-started his design at least once. He got distracted at times, although re-focused with Tahlia's strategy *(task setting)*. He lacked confidence in the success of his design during construction. Engaged with Tahlia's focus strategy *(showing & sharing*) but did not feel ready to test his own. He continued to persevere with his build, although did not complete the roof. Tested blowing his house down on his own at the end of the session, the house stayed up. Continued working on build after session.
Egg Drop Afterschool STEM club (home)	Engaged with Tahlia's initial questions about gravity, eager to provide answers and keen to test out gravity on her own toys. Eager to share initial ideas and responded well to Tahlia's questioning around how to use materials. Her design involved protecting the cup with pom poms, which the egg would fall into. Engaged in less conversations with the others compared to last week. Conversations centred almost exclusively around the task. Was not ready to do the first test. Adapted her design when Tahlia requested the others build *around* the egg. Her modified design involved using a brown paper bag as parachute. Volunteered to drop her egg during second test run, then second-guessed herself at the last minute. Tahlia and the others counted her down to dropping egg. Attempt was unsuccessful. Continued working on build after session.	Engaged with Tahlia's initial questions about gravity, eager to provide answers. Her design involved a landing for the egg. Was eager to share initial progress of her design. Was feeling unwell during this session. Engaged in less conversations with the others compared to last week, and conversations this week centred almost exclusively around the task. First test was successful. Tahlia requested a second design where she built *around* the egg. Built a new structure but struggled to understand the concept of building *around* the egg. Her dad sat nearby for this session, but she was wearing headphones, so he couldn't hear Tahlia's instructions. Second attempt was unsuccessful. Continued working on build after session.	Engaged with Tahlia's initial questions about gravity, eager to provide answers. His design involved protecting the cup with pom poms, which the egg would fall into. Engaged in less conversations with the others compared to last week, and conversations this week centred almost exclusively around the task. Was focused on task for the duration of activity. His mum sat nearby for this session. Was the first to finish his design and his first test was successful. Tahlia requested a second design where they built *around* the egg. He completed this design very quickly; it involved using the paper cup as a parachute and pom poms in the zip lock bag around the egg. Second attempt was unsuccessful. Continued working on build after session.

Ball Run Afterschool STEM club *(home)*	Mum sat with her at the start and the end of the session, and she discussed options and shared progress with her. Worked with her mum rather than talking to the others on screen. When her mum wasn't there, she worked quietly, focused on task and did not engage in many online conversations. When asked, said her ball run "wasn't going well." Responded positively to Tahlia's communication about failure and experimenting, as well as seeing others' designs. Continued to lack confidence in her design as she built, but when she independently tested, she was pleased to find that it worked well. Built a large ball run utilising both Scitech materials and items around her playroom. Briefly paused to watch Tahlia's test ball run. At Tahlia's insistence she did another test run, which was successful. Continued working on build after session.	Didn't wear headphones this week. Dad sat with her, and Chloe discussed options with him throughout and he provided assistance. More focused on working with her dad than talking to others on screen. Did not engage in many conversations online. Built a successful ball run, independently testing as she went. Was keen to share progress with Tahlia as she got close to finishing. Said she found this the most challenging task but was also her favourite. Actively engaged with Tahlia's ball run experiment. Finished her ball run and was eager to share a final test run with everyone, which was successful. Still continued working on build after session.	Was particularly excited when he saw the video demo of a ball run. Appeared chattier this week than last week, at times trying to draw others into conversation and getting a little off task as session went on. Built a ball run that was a straight up-and-down drop. Finished quickly, after only about five minutes although reviewed his design and decided to restart. Was later challenged by Tahlia to extend design, i.e., including a ramp, which he attempted. Sisters were with him towards the end of the session and helped. He remained focused on building towards end of session and continued building during Tahlia's test ball run. His final test run was unsuccessful however he continued working during Tahlia's conclusion and had a successful test just before session ended. Continued working on build after session.
Floating Boats Afterschool STEM club (home)	Engaged and focused on task. Was often hesitant to test construction while it was in progress. Independently tested boat when she felt ready. Initial test was unsuccessful, second test was successful. Continued working on the boat design, turning it into a swan using al foil, paper, and plasticine. This additional weight led to future tests being unsuccessful. Her mum sat with her for parts of the session, providing feedback and encouraging testing. She responded well to Tahlia's strategy of *task setting* (time limits) towards end of session. After an unsuccessful final test, she independently converted her boat to a submarine. Did not engage in many online conversations, and only passively observed Tahlia's demonstrations. She found this task the most challenging, but also enjoyed it. Continued working on build after session.	Session was a one-on-one with Tahlia, as she was unable to attend the usual session time. Engaged with task, appeared comfortable in the one-on-one environment. Dad sat with her throughout session, providing feedback. Had initial ideas and theories about her boat design, responding well to Tahlia's *questioning*. Built a boat with popsticks, plasticine and paper. Needed encouragement from Tahlia and her dad to conduct initial test, which was unsuccessful. After this, she pulled apart her boat and started again. Was inspired by Tahlia's testing of al foil, incorporating this material into her second design along with popsticks and paper. Independently tested design, which successfully floated but could not hold weights. Following this, engaged in range of experiments with Tahlia, testing how plasticine and popsticks could float. Continued working on build after session.	Engaged and visibly excited by the materials, particularly the plasticine. Decided on using just one material for his boat design – al foil. Was eager to test his initial construction. Mum sat with him throughout session, providing feedback. Remained focused on task throughout. Did not engage in many conversations online. Attempted many different designs with his al foil, finding most success with a canoe shaped design. Responded well to Tahlia's strategies of *questioning* and *showing & sharing,* which helped him modify and improve his design. Engaged with Tahlia's experiments, following along at one point. Regularly tested design, and ultimately his boat was able to hold two bolts and three popsticks. Continued working on build after session.

Table 4.1 illustrates the children's levels of engagement during each of the sessions. They were observed actively participating by making, experimenting, predicting, and problem-solving. The children had different experiences during each session in terms of their approach to investigating or designing solutions and experienced varying degrees of success.

4.3 CHILDREN'S PHYSICAL LEARNING ENVIRONMENTS

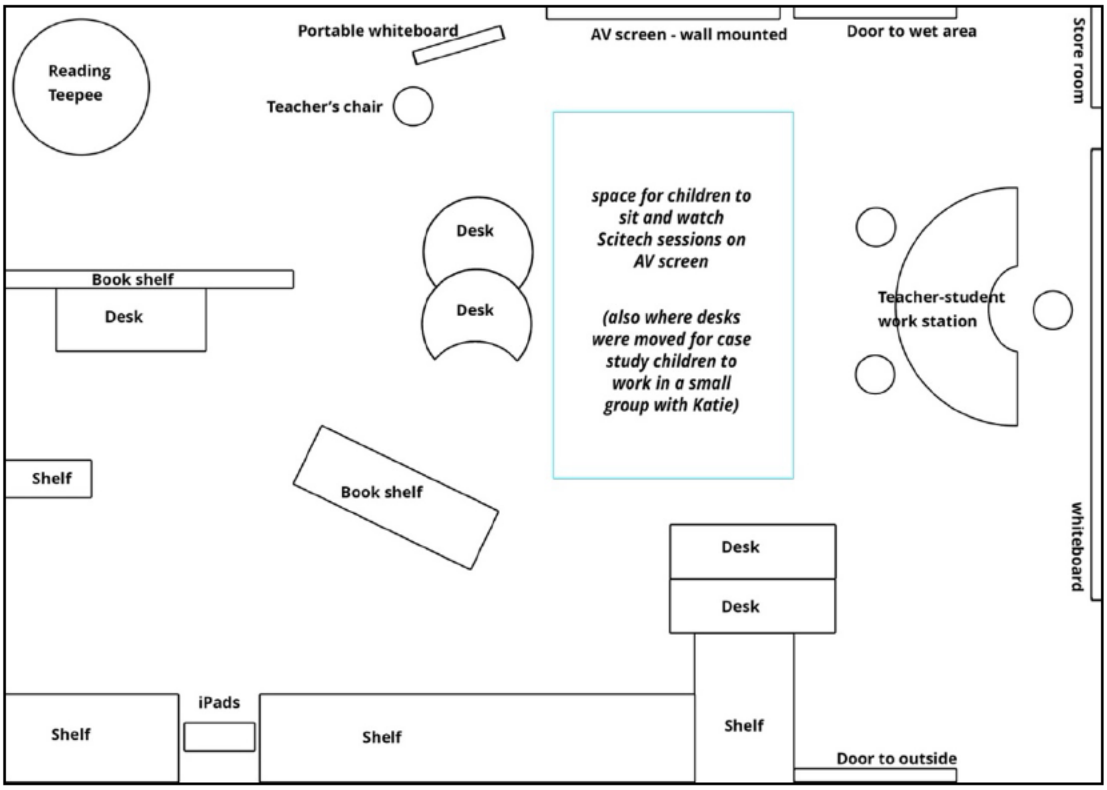
This section includes diagrams that map the children's physical learning environments, specifically their Year 1 classroom where they participated in the school-based Scitech sessions, as well as each of their home learning environments during the afterschool STEM club sessions. Maps were created to provide insight into the impact of the children's physical spaces on their learning. During the data collection phase, the researcher took photographs of each learning environment and used these as references to create diagrams in Adobe Photoshop.

4.3.1 Class environment

The classroom was mapped to visualise the physical space the children were in while engaging in Scitech's school-based online sessions, namely the *Science is Spectacular!* show, the four STEM workshops and the *Quiet as a Mouse* puppet show. The map is presented in Figure 4.1. The set-up of the classroom remained the same for each session.

Figure 4.1

Diagram of children's classroom



In preparation for the online Scitech sessions, the classroom teacher prepared the following:

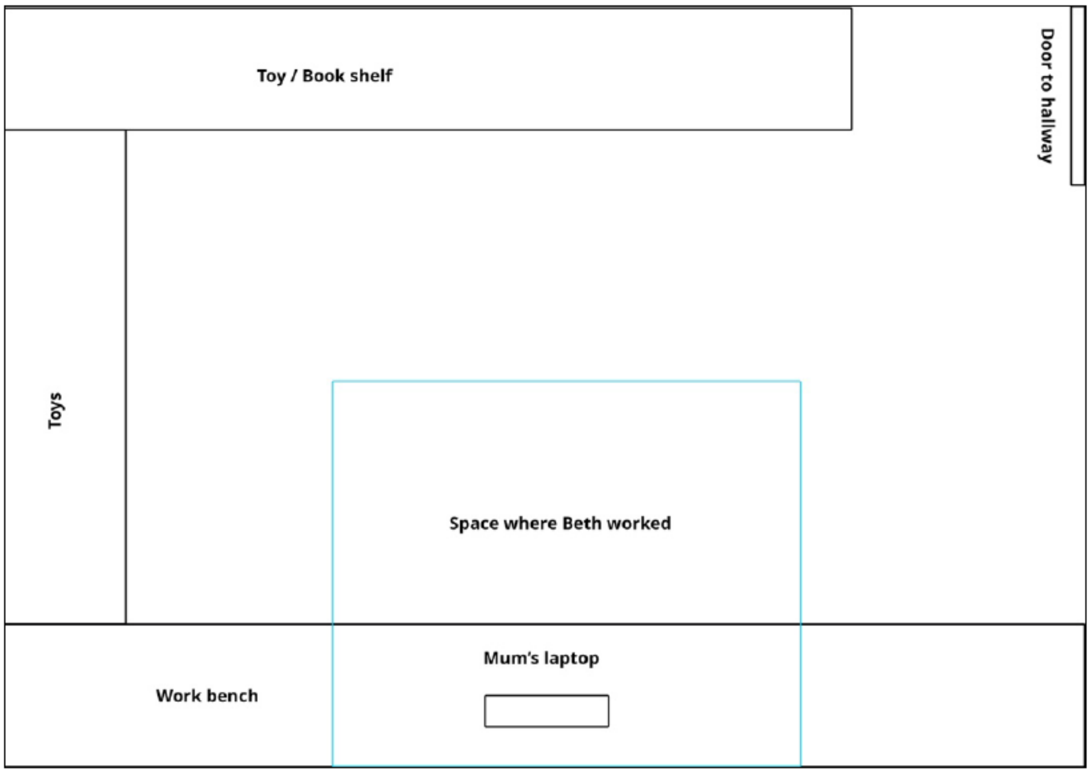
- The classroom teacher's Macbook was connected via HDMI cable to the AV screen, which was mounted on the wall (this is a process classroom teacher had used previously).
- Classroom furniture was moved to one side of the room, so there was enough space for all children to sit on the floor facing the AV screen.
- Tables were moved by the researcher for the case children to work on during the hands-on activities in front of AV screen, once other children had moved to wet area.
- Researcher and classroom teacher stuck butcher's paper on the windows in classroom to reduce glare on AV screen.
- Overhead lights were turned off for the sessions.

4.3.2 Beth's home learning environment

Figure 4.2 shows the layout of Beth's playroom as she participated in each of the afterschool STEM club sessions.

Figure 4.2

Diagram of Beth's playroom



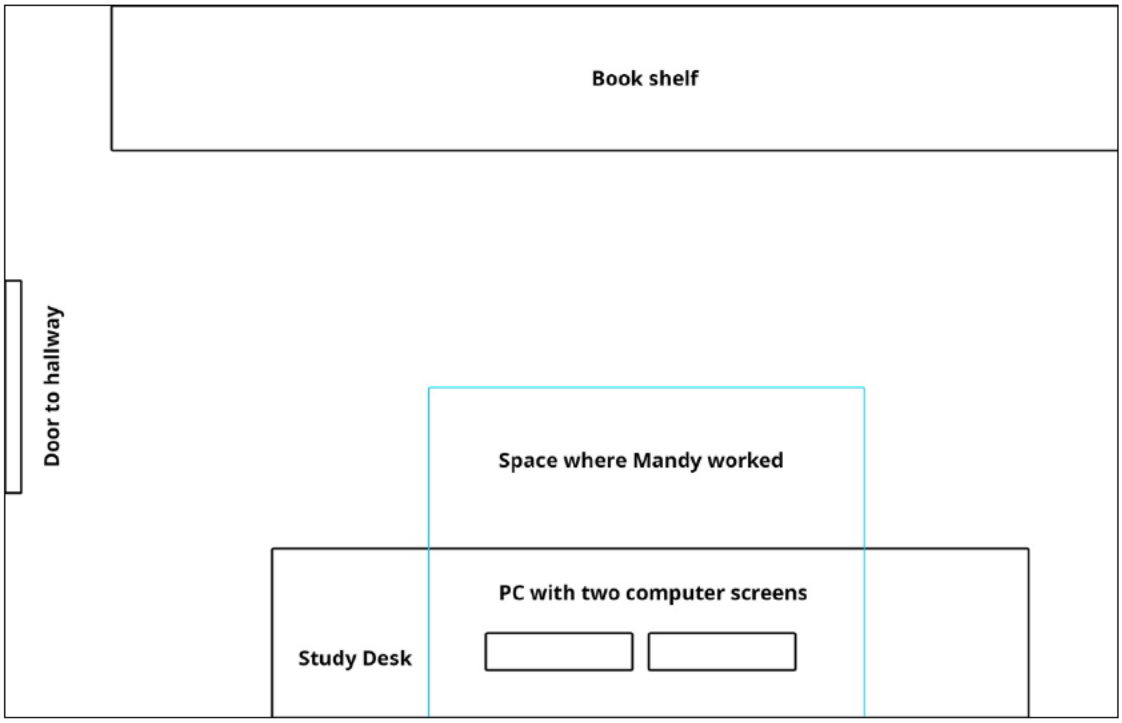
Beth completed each of the afterschool STEM club sessions in her playroom, which she normally shares with her sister. She accessed the Zoom meetings via her mum's laptop, which was set-up on the workbench in front of her. She used the workbench to complete her constructions. There was no other technology observed in the room other than the laptop in use. Beth's mum would enter the room to observe the session and spent time kneeling next to Beth both watching and assisting with her constructions. Other times she moved around the house completing household tasks. Although Beth's younger sister joined her at the start of the first session, she remained in the living room for the rest of the sessions.

4.3.3 Chloe's home learning environment

Figure 4.3 shows the layout of the study where Chloe participated in each of the afterschool STEM club sessions.

Figure 4.3

Diagram of Chloe's study



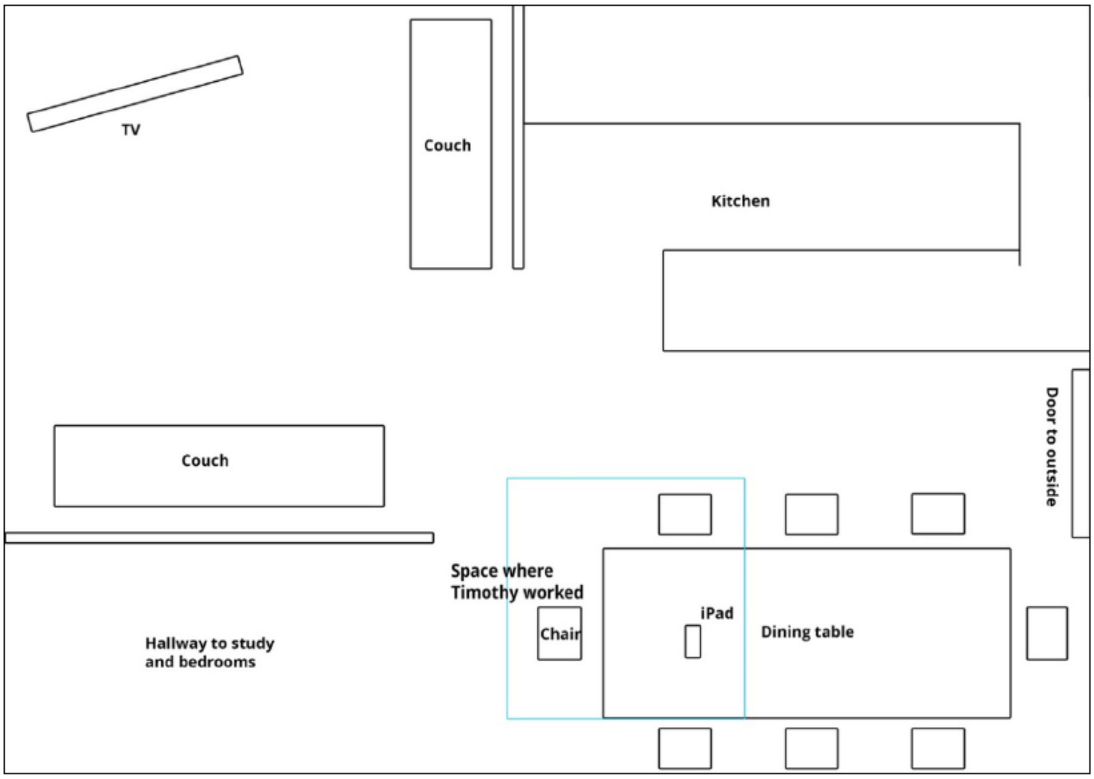
Chloe completed each of the afterschool STEM club sessions in her dad's study. She accessed the Zoom sessions via the PC, which was connected to two computer screens. For the first two sessions she wore headphones, however removed these for the third and fourth session at Tahlia's request. This enabled her dad to hear the instructions directed towards the parents. She used the study desk to complete her constructions. The only technology observed in the room was connected to the PC (i.e., screens, keyboard, mouse). Her mum joined her for the first session, while her dad joined her for the other three sessions. He stayed seated in the room for the duration of the sessions. Her older brother remained in the living room, or attended after school sport, during the sessions.

4.3.4 Jett's home learning environment

Figure 4.4 shows the layout of Jett's living room as he participated in each of the afterschool STEM club sessions.

Figure 4.4

Diagram of Jett's living area



Jett completed all afterschool STEM club sessions at the dining table, in the open-plan dining area next to the kitchen and living room. He accessed the Zoom meetings via his iPad, which was propped up on dining table. He used the dining table to complete his constructions. Other technology in the room included the family TV which was on during the sessions for his grandfather to watch. His mum sat next to him at the dining table for most of the sessions, sometimes leaving to drop siblings off at afterschool sport. At times his siblings or grandfather would sit with him or enter the kitchen to prepare food.

4.4 Development of codes

This section provides a breakdown of the codes developed inductively through V-Note Pro video analysis. These findings provide an overview of the sessions, in terms of the way the Scitech facilitators communicated with the children and the ways the children demonstrated their creativity. Three phases of codes were applied to the video data: *communication types*; *creative moments*; and *focus strategies*.

4.4.1 Frequency of communication types

Table 4.2 provides a combined overview of the frequency of communication types for all the online Scitech sessions. It lists the number of episodes in which each communication type was observed, along with the total duration of time these communication types occurred and the percentage this time makes up of all the data recorded.

Table 4.2

Frequency of communication types (all sessions)

Communication Type	Examples of communication	# episodes	Duration (HH:MM:SS)	% of all data
Dialogic (two-way communication between Scitech and children)	Answering questions Sharing answers/ideas Milly/Tahlia getting children's attention General conversation	558	05:00:09	55.85%
Children-only communication	Sharing predictions with child next to them General conversation among children during afterschool STEM club over Zoom	51	00:18:01	3.36%
No communication to others on Screen	Miss Bird directing children in classroom Children working on their in-class investigations (talking to peers in room) Children working on their at-home projects (talking with parents)	163	01:38:05	18.25%
Scitech-only communication	Milly/Tahlia conducting demonstration Milly/Tahlia giving instructions	243	01:52:59	21.02%
Adult-adult communication	Milly asking Miss Bird for assistance Tahlia and parents in conversation	38	00:04:11	0.78%
	Total	**1053**	**08:53:25**	**99.26%**

Dialogic communication between the Scitech facilitators and the children was the most frequent type of communication (55.85%). The least frequent type of communication was that of adult-adult (0.78%). This highlights the extent to which Milly and Tahlia communicated directly with the children, taking on the role of primary educator during those sessions. The missing 0.74% of time were instances where the researcher spoke directly to participants, or where the video was running prior to a session.

4.4.2 Frequency of creative moments

Table 4.3 provides a combined overview of the frequency of creative moments that occurred during all Scitech sessions. It lists the number of episodes in which each creative moment was observed, along with the total duration of time these creative moments occurred.

Table 4.3

Frequency of creative moments (all sessions)

Creative moments	Examples of creative moments	# episodes	Duration (HH:MM:SS)
Material-based			
Making	Children making maker shakers Children constructing a ball run	375	03:04:34
Experimenting	Children testing if materials could bend, twist, stretch or squash Children testing if boats float	181	02:08:22
Ideas-based			
Predicting	Predicting what will happen to materials during *Science is Spectacular!* show Predicting what materials are in the cups	47	00:43:20
Problem-solving	Children sharing ideas during shows (i.e., how to help Racket the mouse) Children sharing ideas during afterschool STEM club (i.e., impact of gravity on balloon)	93	01:13:09
	Total	**696**	

Table 4.3 shows that of the 1053 episodes, 696 episodes included moments where children were observed demonstrating creativity. Of these 696 episodes, the creative moment of *making* was observed most frequently (375 episodes), while the

creative moment of *predicting* was observed least frequently (47 episodes). There were episodes in which more than one type of creative moment could be applied. For instance, while children were in the process of constructing their boats (making), they would test to see if the boat could float (experimenting). As such, some episodes have more than one creative moment code applied.

4.4.3 Frequency of focus strategies

The third phase of coding was that of *focus strategies*. The purpose of this phase was to help ascertain what enabling communication elements helped foster the children's creativity, as well as the ways in which the facilitators encouraged a positive socio-emotional climate. These are two elements of place: elements of an enabling environment in the *A-E of Children's Creativity* framework. Table 4.4 provides a combined overview of the frequency of focus strategies that occurred during the 696 episodes where creative moments were observed. It lists the number of episodes in which each focus strategy occurred, which is a count of episode frequency, not time duration.

Table 4.4

Frequency of focus strategies (all sessions)

Focus strategies	Examples of focus strategy	# episodes
Extrinsic motivators	"You are doing a really good job" "I'll give you 10 more seconds" "All finished there I see"	54
Questioning	"What do you think is going to happen if I do XYZ?" "When would we want something to bend?"	151
Responding to children	"You're looking for the plastic tube? It's next to the ruler" "Oh yeah, that's very bendy"	110
Show me	"Can you show me how you got your cup to make a sound?" Asking children to show and test their creations during afterschool STEM club	60
Showing and sharing	Tahlia showing focus group the boat she has built and testing it Tahlia narrating what she is doing while building her boat	43
Silence (time to focus)	Children working on their STEM projects or class experiments, Tahlia/Milly quietly watching or constructing themselves	173
Task setting	"Have a think to yourself and then whisper to person next to you. You have 10 seconds… go!" "You said you had finished testing, now I want you to think about why some of these materials were bendy and others weren't" "Show me you're listening"	110
	Total	**701**

Table 4.4 illustrates how the focus strategy of 'questioning' was used most frequency (151 episodes), while the focus strategy of 'showing and sharing' was used least frequently (43 episodes). There were few episodes of creative moments in which more than one focus strategy occurred, resulting in the total number of focus strategy codes being slightly greater than 696.

4.5 NARRATIVE ANALYSIS OF VIDEO DATA

The purpose of this section is to provide rich descriptions of the children's experiences as they engaged in Scitech's sessions, specifically describing how their creativity was fostered and demonstrated. There are twenty-three narrative analysis descriptions included in this section. The structure of each narrative analysis is consistent, as described in Chapter 3. Narrative analysis has been included for each of the Scitech sessions, and in some cases multiple analyses have been included for

Scitech sessions. The descriptions included were selected as they contain moments the researcher felt most suitably reflected the overall tone of that session or included a moment of novelty or interest.

Instances of *place* elements within each narrative were identified deductively, drawing upon the elements from the *A-E of Children's Creativity* framework. Each instance has been given an identifying number and referred to both in the narrative text and the place elements table. As communication is one of the elements of an enabling creative environment, as per the *A-E of Children's Creativity* framework, the types of communications identified during V-Note Pro coding have been included in this table. This served to provide a deeper level of analysis into the way communication occurred during online delivery.

Instances of *process* characteristics within each narrative were identified deductively, drawing upon the process characteristics of the *A-E of Children's Creativity* framework. As with the place elements, each instance has been given an identifying number and referred to both in the narrative text and the process characteristics tables. The types of creative moments identified during coding have been included in this table, providing a deeper level of analysis into the way the creative process unfolded during online delivery. The inclusion of *focus* as one of the creativity processes is included in this section, as it supports the discussion to come in Chapter 5.

4.5.1 *Science is Spectacular!* show #1

Science is Spectacular! was a thirty-minute chemistry-themed demonstration facilitated by Milly, while the children were in their classroom participating through the AV screen. It was the first Scitech session involving the children. The following picture in Figure 4.5 shows the children responding to Milly's question about which animal she should make using her balloon.

Figure 4.5

Children voting for which animal Milly makes with the balloon

Figure 4.5 captures the way Milly involved the children in the demonstration by giving them some agency over the next part of the show. So that she could quickly and easily gauge their votes over the screen, she asked the children to place their hands on either head, nose, or shoulders to indicate which animal they wanted her to make.

Narrative 1: *Science is Spectacular!* show #1

Milly places a giant beaker on the table and informs the children she's going to put something *"very, very, cold"* inside called liquid nitrogen. After experimenting with lettuce leaves and plastic tubes with the liquid nitrogen, Milly produces a balloon (Ob 1). While blowing it up, she asks the children to think about what animal she could turn it into, letting them know that there are three animals she can make: a dog, a worm, or a snake. The children instantly start calling out enthusiastically their choices. As they quieten down, Milly asks them to vote by putting their hands on either their head, nose, or shoulders to indicate which animal they would like her to make (Ob 2). *"Ok, it looks like there's a lot of hands-on heads"* she says, squinting at the screen, *"so you want me to make a dog… Ok, are you ready? Three, two, one!"* (Ob 3). She comically tries and fails to create a dog before grabbing a pre-made one from under her bench (Ob 4). From there, she proceeds to experiment with the balloon and liquid nitrogen (Ob 5). Table 4.5 lists the place elements that were observed during the described narrative above.

Table 4.5

Place elements observed during Science is Spectacular! show #1

PLACE					
Resources		**Communication**		**SE climate**	
Intentional provocations	Not observed	Intentional learning conversations	Ob 2	Stress and pressure free environment	Ob 1, 4
Stimulating materials	Ob 1, 4	Hearing and valuing children's ideas	Ob 3	Non-prescriptive	Not observed
Adequate materials for everyone	Not observed	Open inquiring questioning	Not observed	Non-judgemental	Ob 3
Time for creative exploration	Not observed	Facilitating dialogic conversations	Ob 2	Allowed to make mistakes	Ob 4

TYPES OF COMMUNICATION				
Adult-adult	**Children-only**	**Dialogic**	**None on screen**	**Scitech-only**
Not observed	Not observed	Ob 2	Not observed	Ob 3

The table indicates that only one Resource element was observed. This observation can be attributed to the nature of the *Science is Spectacular!* show, in which its purpose was for Milly to demonstrate scientific experiments to the children. They were given the opportunity to have input and make predictions, which accounts for the higher levels of communication elements observed. The types of communication observed reflects the structure of the show, in which Milly spent time talking directly to the children, as well as engaging in two-way conversations when asking for input or predictions.

Table 4.6 lists the process characteristics that were observed during the described narrative above.

Table 4.6

Process characteristics observed during Science is Spectacular! show #1

PROCESS					
Agency	**Being Curious**	**Connecting**	**Daring**	**Experimenting**	**Focus**
Ob 2	Ob 1	Not observed	Not observed	Ob 1, 5	Ob 2, 5

CREATIVE MOMENTS			
Experimenting	**Making**	**Problem-solving**	**Predicting**
Ob 1, 5	Not observed	Not observed	Not observed

The only creative moment observed during this episode was that of *experimenting*. This finding aligns with the purpose of the *Science is Spectacular!* show, which was to engage children in demonstrations, as opposed to hands-on investigations.

4.5.2 ***Science is Spectacular!* show #2**

Science is Spectacular! was a thirty-minute chemistry-themed demonstration facilitated by Milly, while the children were in their classroom. The following picture in Figure 4.6 captures Milly holding up the results of their elephant toothpaste experiment to the screen.

Figure 4.6

Children engaged in Science is Spectacular! show

Figure 4.6 shows how Milly was able to provide the children with a close-up view of what happened when she mixed the materials together. Although the faces of the children are blurred for privacy, each child's eyes were fixated on the screen in interest as they listened to Milly's scientific explanation.

Narrative 2: *Science is Spectacular!* show #2

For thirty minutes the class stared transfixed at the AV screen while Milly presented several different, eye-catching experiments. At this point in the show, she put on her gloves and asked the children how much of each ingredient she should pour into the large glass beaker. Both times, the class called out *"all of it"* and she responded by pouring in liberal amounts (Ob 6). The children could not take their eyes off the screen as she did this, with Chloe saying to herself aloud what she thought would happen (Ob 2). *"Are you ready to find out what the science reaction is?"* Milly called out, *"you might need to zoom out a little for this one, it can get pretty messy* [camera zooms out] *count down with me everyone.*" The children counted down enthusiastically as Milly gestured with her fingers. She poured the final ingredient in and waited for a reaction which doesn't come. *"What a shame…do you want to guess what I was hoping would happen?"* After listening to a few predictions, Milly explained the chemical reaction that was meant to happen (Ob 3). *"But you can tell a reaction is happening*" she said, as she carried the beaker up close to the camera. Milly then moved onto a different experiment, lighting her hand on fire. The class called out in amazement, saying things like, *"wow!"* and *"that's so cool.*" Chloe was still engrossed in Milly's performance, turning at this point to talk excitedly to another child about what they had seen. Suddenly, the initial 'failed' experiment in the beaker suddenly began to erupt. Chloe and the other children called out excitedly to let Milly know, and the camera zoomed in to show the chemical reaction in more detail. Table 4.7 lists the *place* elements that were observed during the described narrative above.

Table 4.7

Place elements observed during Science is Spectacular! Show #2

PLACE					
Resources		**Communication**		**SE climate**	
Intentional provocations	Not observed	Intentional learning conversations	Ob 3	Stress and pressure free environment	Ob 3
Stimulating materials	Ob 1	Hearing and valuing children's ideas	Ob 1	Non-prescriptive	Not observed
Adequate materials for everyone	Not observed	Open inquiring questioning	Ob 3	Non-judgemental	Not observed
Time for creative exploration	Not observed	Facilitating dialogic conversations	Not observed	Allowed to make mistakes	Ob 3

TYPES OF COMMUNICATION				
Adult-adult	**Children-only**	**Dialogic**	**None on screen**	**Scitech-only**
Not observed	Not observed	Ob 1	Not observed	Ob 3

Table 4.7 indicates that four of the possible twelve place elements were observed during this episode. This finding could be attributed to the nature of the *Science is Spectacular!* show, in which its purpose was for the children to observe demonstrations. The types of communication observed reflects this structure, in which Milly spent time talking directly to the children (Ob 3), as well as engaging in two-way conversations (Ob 1) when asking for input. Table 4.8 lists the process characteristics that were observed during the described narrative above.

Table 4.8

Process characteristics observed during Science is Spectacular! Show #2

PROCESS					
Agency	**Being Curious**	**Connecting**	**Daring**	**Experimenting**	**Focus**
Ob 1	Ob 2	Not observed	Not observed	Ob 2	Ob 2

CREATIVE MOMENTS			
Experimenting	**Making**	**Problem-solving**	**Predicting**
Ob 2	Not observed	Not observed	Not observed

The only *creative* moment observed during this episode was that of experimenting. This finding aligns with the purpose of the *Science is Spectacular!* show, which was to excite and engage children by presenting demonstrations they may not witness in the classroom, as opposed to offering hands-on investigations.

4.5.3 Mini Volcanos

Mini Volcanos was a classroom teacher-led activity where children created their own volcanos on the school basketball court. Classroom teachers used the materials and instructions provided to them by Scitech to complete this activity. The following day, the children saw Milly on the AV screen in their classroom for their first STEM workshop. At the start of the workshop, Milly questioned them about the success of their mini volcanos. Figure 4.7 shows the moment the children's volcanos erupted.

Figure 4.7

Children reacting to their volcano eruptions

Figure 4.7 captures the excitement of the children as their volcano experiment successfully erupts. The group standing has placed their volcano experiment on the ground. The boy in the red jumper held his group's volcano experiment in his hand. Although their faces are blurred for privacy, their body language reflects how they were jumping up and down in excitement, demonstrating their focus and engagement in the activity.

Narrative 3: *Mini Volcanos*

Mini Volcanos on the basketball court

The two classroom teachers stood in the middle of the basketball court, loudly outlining the instructions to the groups of excited children. Beth, Chloe, Jett and two other children were working in two groups next to each other. They diligently followed their teachers' instructions, using pipettes to fill their vials with detergent and vinegar and adding bi-carb soda into the vial lid (Ob 1). While waiting for their classmates to finish their preparation, the children explored the volcano ingredients in front of them, sniffing the detergent and touching the bi-carb soda (Ob 2). Jett's partner even licked the bi-carb soda when they thought no one was watching. Together, the teachers and children counted down from five to one before placing the vial lids onto their vials and shaking. Beth and Chloe's group removed the lid and stepped back to watch, jumping up and down in excitement as it overflowed from the vial. Meanwhile, Jett and his partner continued to give their vial an extra shake before watching the eruption. Their volcano experiments were a success. As the teachers wandered around to visit each of the groups, the children used this unstructured time to explore. They tried touching the foam, discussing with one another about how it felt. They encouraged one another to put the lid on and off, and poke and mix the foam mixture to see what would happen (Ob 3). Even when the teachers called for attention, the children were still eagerly experimenting.

Follow-up conversation with Milly

The class was seated on the mat in front of the AV screen, waiting for their first STEM workshop session to begin. This was the first time they had seen Milly since they completed their Mini Volcano experiment the day before. Milly began to introduce the session, but then said, *"First, I want to know how you went with your* *volcano activity yesterday. Did you like that one?"* the class responded affirmatively, and Milly then asked if anyone wanted to share what happened during the experience (Ob 4). About half the class put up their hand and Jett was chosen by the teacher to share. *"It was so fun that it exploded so high!"* he said. Milly laughed and asked, *"Yeah, how high did we get? Was it so high it went over your heads* [gesturing]?!" The class responded by calling out "*no*" and Jett said, *"just this high"* and gestured with his hands. Milly asked the teacher to choose some other children to share their experiences, listened attentively as they did (Ob 5). To conclude this conversation, she said, *"Oh sweet, so it went up and bubbled over, that is super-duper. Well, I'm glad you had that experience doing some experimenting because we are going to keep on experimenting today."* And with that, she launched into the session's activity (Ob 6). Table 4.9 lists the *place* elements that were observed during the described narrative above.

Table 4.9

Place elements observed in during Mini Volcanos (Basketball Court)

PLACE					
Resources		**Communication**		**Socio-emotional climate**	
Intentional provocations	Not observed	Intentional learning conversations	Ob 4	Stress and pressure free environment	Ob 2, 5
Stimulating materials	Ob 1	Hearing and valuing children's ideas	Ob 5	Non-prescriptive	Not observed
Adequate materials for everyone	Ob 1	Open inquiring questioning	Not observed	Non-judgemental	Ob 5
Time for creative exploration	Ob 2	Facilitating dialogic conversations	Not observed	Allowed to make mistakes	Ob 2, 5

TYPES OF COMMUNICATION				
Adult-adult	**Children-only**	**Dialogic**	**None on screen**	**Scitech-only**
Not observed	Not observed	Ob 4, 5	Ob 1, 2, 3	Ob 6

As there was no online delivery component to the *Mini Volcano* activity on the basketball court, the only type of communication observed was that of None on screen. The children were provided with enough materials for them each to participate and time to explore. During the activity, the classroom teachers were not observed engaging in inquiry questioning or dialogic conversation, instead they focused on walking around to ensure each group was on task. Table 4.10 lists the process characteristics that were observed during the described narrative above.

Table 4.10

Process characteristics observed during Mini Volcanos (Basketball Court)

PROCESS					
Agency	**Being Curious**	**Connecting**	**Daring**	**Experimenting**	**Focus**
Not observed	Ob 2, Ob 3	Not observed	Not observed	Ob 1	Ob 1, Ob 3

CREATIVE MOMENTS			
Experimenting	**Making**	**Problem-solving**	**Predicting**
Ob 1	Not observed	Not observed	Not observed

The table reflects the experimental nature of the *Mini Volcano* activity on the basketball court, as the children were observed engaging in the creative moment of experimenting. They were curious and focused on the activity and followed a prescribed set of instructions provided by Scitech and delivered by the classroom teachers.

4.5.4 *Bend, Twist, Stretch & Squash* #1

Bend, Twist, Stretch & Squash was the first school-based STEM workshop the children participated in with Milly. Children investigated different items to see if they could be changed by physical force. Figure 4.8 shows the children as they begin their investigation with the different items.

Figure 4.8

Chloe using both hands to manipulate the stone

Figure 4.8 captures the children's focus as they use their hands to manipulate the different items provided to them by Scitech. Milly provided instructions and support, as the children investigated. She held up materials to the screen to help explain to the children what they needed to do.

Narrative 4: ***Bend, Twist, Stretch & Squash* #1**

Milly had finished a class discussion where she used green screen technology to project different materials onto the screen behind her, before helping the children practice how to bend, twist, stretch, and squash with their hands while she demonstrated on the screen. Following this, the children moved to their tables to begin their own investigation. *"You can start testing, I'll just watch you for now"* Milly said, as the investigation materials were handed out by the researcher to each child. Chloe had been listening carefully to Milly's instructions, then she put her head down and began reviewing her recording sheet (Ob 1). Amidst the surrounding noise of the other children discussing their initial discoveries, Chloe remained silent and focused. She started with the stone, occasionally setting down her pencil so that she could use both hands to experiment whether it can be bent, stretched, twisted, or squashed. *"All the stones are 'no'"* she reflected aloud, before moving onto the next item (Ob 2). She remained engaged and concentrated on the task, taking time to perform each manipulation, and continued to set aside her pencil when necessary to use both hands. When Milly asked the others, *"Why does playdough change shape if you squash it?"* Chloe interjected to say, *"Because it's flexible"* (Ob 3). While two of her peers finished the investigation early, she did not finish before it was time to pack up. When the class gathered on the mat to reflect on their findings, she raised her hand each time to offer her findings (Ob 4). Table 4.11 lists the place elements that were observed during the described narrative above.

Table 4.11

Place elements observed in Bend, Twist, Stretch & Squash #1

PLACE					
Resources		**Communication**		**SE climate**	
Intentional provocations	Not observed	Intentional learning conversations	Not observed	Stress and pressure free environment	Ob 1, 2
Stimulating materials	Ob 2	Hearing and valuing children's ideas	Ob 3	Non-prescriptive	Not observed
Adequate materials for everyone	Ob 1, 2	Open inquiring questioning	Not observed	Non-judgemental	Ob 3, 4
Time for creative exploration	Ob 2	Facilitating dialogic conversations	Ob 3	Allowed to make mistakes	Not observed

TYPES OF COMMUNICATION				
Adult-adult	**Children-only**	**Dialogic**	**None on screen**	**Scitech-only**
Not observed	Not observed	Ob 3, 4	Ob 2	Ob 1

The table illustrates how the children followed a prescribed set of instructions to investigate the way different materials could bend, twist, stretch, and squash. Eight different materials were an adequate number for the four children at the table as they did not have to wait for an item to investigate, and they were given time by Milly to independently explore. Milly acknowledged their ideas as they shared them and engaged in dialogic conversations. She did not place pressure on the children to find the 'right' answers, rather she encouraged them to use their hands to investigate themselves. Table 4.12 lists the process characteristics that were observed during the described narrative above.

Table 4.12

Process characteristics observed during Bend, Twist, Stretch & Squash #1

PROCESS					
Agency	**Being Curious**	**Connecting**	**Daring**	**Experimenting**	**Focus**
Not observed	Ob 1, 2	Ob 3	Not observed	Ob 2	Ob 1, 2

CREATIVE MOMENTS			
Experimenting	**Making**	**Problem-solving**	**Predicting**
Ob 2	Not observed	Ob 3	Ob 2

The children demonstrated characteristics of curiosity, experimenting, and focus as they investigated the different materials. Intentional scaffolding provided opportunity for the children to predict what the materials would do before experimenting. Chloe engaged in the creative moment of problem-solving when she considered responses to Milly's questions about why materials behave in certain ways.

4.5.5 *Bend, Twist, Stretch & Squash #2*

Bend, Twist, Stretch & Squash was the first school-based STEM workshop the children participated in with Milly. After investigating whether different items could be manipulated, they followed Milly's directions to make slime. Figure 4.9 shows the children half-way through their slime experiment.

Figure 4.9

Children follow along as Milly demonstrates how to make slime

Figure 4.9 captures Milly as she demonstrated the steps to make slime, while the children followed along. Although their faces have been blurred for privacy, the children are engaged and focused on mixing their slime ingredients together.

Narrative 5: *Bend, Twist, Stretch & Squash #2*

Milly instructed the four children to open their zip-lock bags, holding her own up to the camera to demonstrate. Jett watched closely to ensure he was following correctly, and eagerly awaited his turn to scoop the slime ingredients into his bag (Ob 1). He bounced around at first, even leaning over the desk at one point to watch as the others have their turn. Milly continued to guide the children through the steps, allowing them to choose red or blue dye (Ob 2). Jett chose red, and enthusiastically squished and squeezed the contents of his bag. Milly asked the group if their mixtures were slimy yet, to which they replied *"no."* She asked them to consider what they needed to add more of, to which the children replied, *"more slime powder"* (Ob 3). Over the following five minutes, Jett remained focused on experimenting with the consistency of his slime. He independently alternated between adding more slime powder and more red dye (Ob 4). He moved around the table, looking at other children's slime, but did not participate in many conversations with either his classmates or Milly. When Milly asked him to predict what the extra dye would do to the consistency of his slime, he replied with *"I don't know,"* (Ob 5) appearing eager to simply add the ingredient and find out. Although his slime did not reach the consistency, he was aiming for stating at the end, *"mine is not even slime!"* he did not appear disheartened (Ob 6). He continued squishing, shaking, and squashing his zip-lock bag right up until the end of the lesson. Table 4.13 lists the place elements that were observed during the described narrative above.

Table 4.13
Place elements observed in Bend, Twist, Stretch & Squash #2

PLACE					
Resources		**Communication**		**Socio-emotional climate**	
Intentional provocations	Not observed	Intentional learning conversations	Ob 3	Stress and pressure free environment	Ob 3, 6
Stimulating materials	Ob 1	Hearing and valuing children's ideas	Ob 3	Non-prescriptive	Not observed
Adequate materials for everyone	Ob 1	Open inquiring questioning	Ob 3, 5	Non-judgemental	Ob 3, 6
Time for creative exploration	Ob 4, 6	Facilitating dialogic conversations	Not observed	Allowed to make mistakes	Ob 6

TYPES OF COMMUNICATION				
Adult-adult	**Children-only**	**Dialogic**	**None on screen**	**Scitech-only**
Not observed	Not observed	Ob 1, 3, 5	Ob 4, 6	Ob 2

Table 4.13 illustrates how the children followed a prescribed series of instructions to create their own slime. They had adequate time and materials and were allowed to experiment and make mistakes as they experimented with different amounts of the ingredients. Milly was observed engaging in intentional learning conversations, questioning, and listening to the children's ideas. The children communicated with Milly on the AV screen, as well as with one another in the classroom. Table 4.14 lists the process characteristics that were observed during the described narrative above.

Table 4.14

Process characteristics observed in Bend, Twist, Stretch & Squash #2

PROCESS					
Agency	**Being Curious**	**Connecting**	**Daring**	**Experimenting**	**Focus**
Ob 2, 4	Ob 4, 6	Ob 3	Ob 4, 6	Ob 1, 4, 6	Ob 1, 4, 6

CREATIVE MOMENTS			
Experimenting	**Making**	**Problem-solving**	**Predicting**
Ob 1, 4, 6	Not observed	Ob 3, 4	Ob 5

All creativity processes were observed in the children as they completed the slime making activity. They engaged in creative moments of experimenting as they made the slime, problem-solving as they explored how to improve the consistency of the slime and were prompted by Milly to predict what would occur before adding more ingredients to their bags. As the children were following a series of prescribed sets to conduct an experiment, the creation of their slime was not classified as a creative moment of making.

4.5.6 *Sound Cups* #1

Sound Cups was the second school-based STEM workshop the children participated in with Milly. Children explored how sound travels through vibrations using cups and string. Figure 4.10 shows a demonstration led by Milly which occurred following the children's independent investigation of sound vibrations.

Figure 4.10

Milly engaging children in a conversation about sound vibrations

Figure 4.10 captures Milly's demonstration of what happens when she tried to make sound with her string without the cup. Alongside her, with the use of green screen

technology, is an illustrated diagram of the process. Although the children's faces have been blurred for privacy, they were watching the AV screen with interest as they participated in this conversation with Milly.

Narrative 6: *Sound Cups* #1

The class had just returned to the mat after completing their sound cups investigation. *"I want to know what you thought about the noises your cups made?"* Milly asked, then listened attentively as the teacher selected some children to respond (Ob 1). Responses included, *"it sounded like rain falling on a tin roof"* and *"it kinda sounded like something dragging on the floor"* (Ob 2). Following, this, Milly picked up some props and showed them to the camera, *"I have some string and a paperclip here like you had with your cups, but if I rub this* [rubs string with cloth] *I don't get the same noises…why can't I hear it here, but I can hear it when I put the cup on top? Does anyone have any guesses?"* One child suggested, *"Because the cup is harder than the string, that's why."* Milly responded to this suggestion by saying, *"Yep, pretty good theory there. What our cup is doing is it is making the noise louder"* and goes onto to share the scientific explanation (Ob 3). Milly then picked up another prop, a slinky. *"I want you to try and guess what kind of sound a slinky might make. I have my big amplifier here so hopefully we can hear it. I'll give you ten seconds to make your guess."* Lots of *"shhhh-shhhh"* noises filled the room as the children turned to one another and eagerly began making their guesses (Ob 4). Table 4.15 lists the place elements that were observed during the described narrative above.

Table 4.15

Place elements observed in Sound Cup #1

PLACE					
Resources		**Communication**		**SE climate**	
Intentional provocations	Not observed	Intentional learning conversations	Ob 1, 3	Stress and pressure free environment	Ob 1, 3, 4
Stimulating materials	Ob 3, 4	Hearing and valuing children's ideas	Ob 1, 3	Non-prescriptive	Not observed
Adequate materials for everyone	Not observed	Open inquiring questioning	Ob 1, 3, 4	Non-judgemental	Ob 1, 3
Time for creative exploration	Ob 4	Facilitating dialogic conversations	Ob 3	Allowed to make mistakes	Ob, 3

TYPES OF COMMUNICATION				
Adult-adult	**Children-only**	**Dialogic**	**None on screen**	**Scitech-only**
Ob 1	Ob 4	Ob 1	Not observed	Ob 3

This table illustrates how Milly engaged the class in learning conversations and questioning, allowing them to share ideas without judgement. While Milly herself demonstrated with a stimulating material, the children did not have materials themselves to work with during this episode. Table 4.16 lists the process characteristics that were observed during the described narrative above.

Table 4.16

Process characteristics observed in Sound Cups #1

PROCESS					
Agency	**Being Curious**	**Connecting**	**Daring**	**Experimenting**	**Focus**
Not observed	Ob 4	Ob 2	Not observed	Ob 3	Ob 3, 4

CREATIVE MOMENTS			
Experimenting	**Making**	**Problem-solving**	**Predicting**
Not observed	Not observed	Ob 3	Ob 4

During the class discussion the children were prompted by Milly to consider solutions and make predictions. As such, they were observed making connections between the hands-on activity they had just finished and their prior knowledge of slinkys and the demonstration Milly was doing on the AV screen.

4.5.7 *Sound Cups #2*

Sound Cups was the second school-based STEM workshop the children participated in with Milly. After exploring how sound travels through vibrations using cups and string, the children were challenged to create a ‘telephone’ using the same materials. Figure 4.11 shows the children experimenting in pairs with their ‘telephones.’

Figure 4.11

Children experimenting to make telephones out of cups and string

Figure 4.11 captures the children as they actively engage in their ‘telephone’ challenge. Milly watched on from the AV screen while the children attempted to talk and listen to one another throughout the cups. Beth began to walk backwards to pull the string tighter. The position of the AV screen on the wall allows Milly and the children to still interact with one another.

Narrative 7: *Sound Cups* #2

Attaching two paper cups together with string, the children worked in pairs to construct make-shift telephones. After having some time to spread out around the classroom and experiment, Milly brought them back around the table (Ob 1). *“I want you to see if there’s a difference talking to your friend when the string is really loose, compared to when the string is really tight”* she said. The children spread out across the classroom once more. Jett and Beth were working together and appeared to have figured out how to make the telephone work on their own. They stood far apart, their string pulled tight and took turns speaking and listening through their cups (Ob 2). Meanwhile, the other two children stood closer to one another, calling out funny words and phrases into the cups, the string hanging limp on the floor. Milly continued to encourage them to pull their string tighter. With a few minutes left to experiment, Milly posed the ultimate challenge: can they find a way to create a functioning four-way telephone? Despite being off task initially, the children managed to intertwine their telephones, standing at opposite ends of the classroom and yelling into their cups. "*That totally worked!*" one of the children exclaimed. "*Amazing!*" responds Milly (Ob 3). Table 4.17 lists the place elements that were observed during the described narrative above.

Table 4.17

Place elements observed in Sound Cups #2

PLACE					
Resources		**Communication**		**Socio-emotional climate**	
Intentional provocations	Not observed	Intentional learning conversations	Not observed	Stress and pressure free environment	Ob 1, 2
Stimulating materials	Ob 1	Hearing and valuing children's ideas	Ob 3	Non-prescriptive	Not observed
Adequate materials for everyone	Ob 1	Open inquiring questioning	Ob 1	Non-judgemental	Ob 1, 3
Time for creative exploration	Ob 1, 2	Facilitating dialogic conversations	Not observed	Allowed to make mistakes	Ob 1, 2
TYPES OF COMMUNICATION					
Adult-adult	**Children-only**	**Dialogic**	**None on screen**	**Scitech-only**	
Not observed	Not observed	Ob 3	Ob 1, 2	Ob 1	

Several place elements were observed during the telephone cups challenge. The children were provided with enough materials to engage in a group telephone challenge and had time to explore and experiment. The activity was prescriptive in that Milly asked them specifically to create a telephone out of the string and cups provided. The lack of dialogic conversation between Milly and the children can be attributed to the children's focus on completing the challenge with one another. Table 4.18 lists the process characteristics that were observed during the described narrative above.

Table 4.18

Process characteristics observed during Sound Cups #2

PROCESS					
Agency	**Being Curious**	**Connecting**	**Daring**	**Experimenting**	**Focus**
Ob 1, 2	Ob 1, 2	Ob 2	Ob 1, 2	Ob 1, 2	Ob 1, 2

CREATIVE MOMENTS			
Experimenting	**Making**	**Problem-solving**	**Predicting**
Ob 1, 2	Not observed	Ob 2	Not observed

All creative processes were observed as the children engaged in this activity. Specifically, the children experimented and problem-solved to transform their materials into a functional telephone. As the children were following a series of prescribed steps to piece the cups and string together, the creation of the telephone was not classified as a creative moment of making.

4.5.8 *What's in the Cup?*

What's in the Cup? was the third STEM school-based workshop the children participated in with Milly. Children participated in a scientific investigation, making predictions about the different sounds concealed within cups. Figure 4.12 captures Jett as he shares the findings of his investigation with Milly.

Figure 4.12

Jett showing Milly his completed investigation

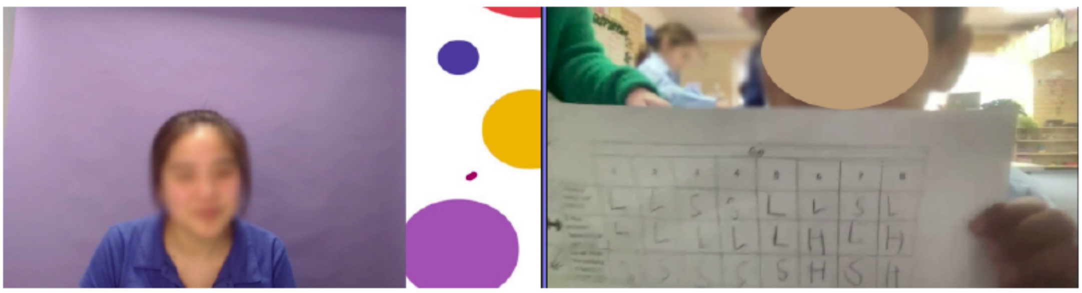


Figure 4.12 shows how Jett brought his completed findings up close to the AV screen to discuss them with Milly. Milly leant in so she could read how he described each of the materials concealed within the cups. The other children were able to continue their own independent investigation while they had this conversation.

Narrative 8: ***What's in the Cup?***

"Show me you're listening," Milly put her hands on her head. The five children continued to shake the cups full of mystery materials, trying to guess what was inside. *"Show me you're listening,"* Milly put her hands on her nose, ears, eyes, head, and mouth (Ob 1). One-by-one the children noticed what she was doing, put down the cups, and followed along. After 27 seconds, she had their full attention. She proceeded to outline the instructions for the investigation after which, Jett enthusiastically reached for his first cup and gave it a quick shake before recording how loud it sounded and how heavy it felt. There was happy chatter around the room as the children shook cups and called out to one another and Milly what they thought was in their cups. *"Milly, this is mine – this is rice!"* Jett called out confidently (Ob 2). However, when one of the other children began flipping the cups for fun, Jett and the others instantly joined in. Milly quickly pulled their focus back to the AV screen saying, *"Show me you're listening!"* before reminding them of the task at hand. Jett immediately recommenced the task. As time went on, he spent longer shaking each cup, leaning in close to listen, before writing down his findings (Ob 3). At one point, he was so focused that he failed to hear Milly when she called out to ask specifically how he was progressing. He did not engage in the conversations around him, although at one point he again called out to Milly, *"this one is bottle tops."* She asked what made him think that and he responded simply, *"It's because, it sounds like bottle tops."* She prompted him with another question, *does it feel heavy or light?"* and he responds that it felt light (Ob 4). He was the first of the group to finish and held his worksheet up for Milly to see (Ob 5). She said *"Great job, Jett"* before directing him to the last part of the worksheet which was to use his observations to make a prediction about what material was in each cup. He ran back to his desk and worked quietly, returning to re-shake the cups to make his final predictions. When the child next to him was off task again, he paid no attention to him. Table 4.19 lists the place elements that were observed during the described narrative above.

Table 4.19

Place elements observed in What's in the Cup?

PLACE					
Resources		**Communication**		**SE climate**	
Intentional provocations	Not observed	Intentional learning conversations	Ob 4, 5	Stress and pressure free environment	Ob 2, 4
Stimulating materials	Ob 2	Hearing and valuing children's ideas	Ob 2, 5	Non-prescriptive	Not observed
Adequate materials for everyone	Ob 2	Open inquiring questioning	Ob 4	Non-judgemental	Ob 2, 4
Time for creative exploration	Ob 2	Facilitating dialogic conversations	Not observed	Allowed to make mistakes	Ob 2, 4

TYPES OF COMMUNICATION				
Adult-adult	**Children-only**	**Dialogic**	**None on screen**	**Scitech-only**
Not observed	Not observed	Ob 2, 4, 5	Ob 3	Ob 1

Table 4.19 illustrates how the children followed a prescribed set of instructions to investigate the different sounds within each cup. Eight different cups were an adequate number for the five children at the table, as no one had to wait for a cup. They were given time by Milly to independently shake and investigate. Milly acknowledged their ideas as they shared them and asked follow-up questions about their predictions. She did not place pressure on the children to find the 'right' answers but rather encouraged them to use their senses to consider what materials could be in each cup. Conversations were not observed as Milly strategically gave the children time to complete their investigation. Table 4.20 lists the process characteristics that were observed during the described narrative above.

Table 4.20

Process characteristics observed in What's in the Cup?

PROCESS					
Agency	**Being Curious**	**Connecting**	**Daring**	**Experimenting**	**Focus**
Not observed	Ob 2, 3, 5	Ob 2, 4, 5	Ob 2, 3	Ob 2, 3	Ob 2, 3

CREATIVE MOMENTS			
Experimenting	**Making**	**Problem-solving**	**Predicting**
Ob 2, 3	Not observed	Ob 4	Not observed

The children demonstrated processes of curiosity, experimenting, and focus as they investigated the different materials. They also were observed making connections with prior knowledge to make predictions and were tolerating uncertainty as they did so. Jett engaged in the creative moment of problem-solving when he considered responses to Milly's questions about the materials he could hear and feel within the cups.

4.5.9 *DIY Shakers* #1

DIY Shakers was the fourth STEM school-based workshop the children participated in with Milly. Children designed and created their own musical instrument ('maker shaker') using materials provided by Scitech, in preparation for the upcoming puppet show, *Quiet as a Mouse*. Figure 4.13 shows the children working on the creation of their shakers.

Figure 4.13

Beth solving a problem during DIY Shakers

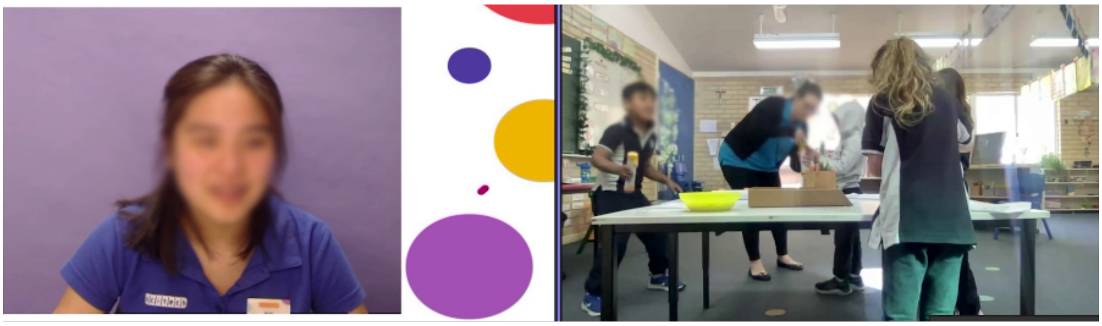


Figure 4.13 illustrates Milly giving the children time to create but is carefully watching and ready to provide feedback or support. Beth has moved around the table so that she can experiment with a different way of transferring rice into her tube, following a conversation about problem-solving with Milly and the other children. The researcher is seen providing fine motor skill support to the children as they attach the elastic bands around their tubes.

Narrative 9: *DIY Shakers* #1

"Ok, you can start building. I want to see how you end up building your designs" Milly said, as the children stood around the desks. They each had their own paper roll and were focused on constructing their maker shaker (Ob 1). Beth worked quietly, occasionally glancing around at the others as she covered one end of the tube with paper. *"It looks like Beth is doing a very good job scrunching that paper around the tube, great job there"* Milly calls out (Ob 2). *"It's getting messy"* one of the children announced to the room as they attempted to move the rice from the bowl

with their fingers and drop it into their tube. *"How might you get your rice to your tube without getting it all over the table? That might be a tricky problem to solve."* Milly prompted them. "[You could pick up] *some smaller bits"* the child responds. Milly considered their response, saying *"Yeah, use some smaller bits, that's a good way to do it."* She paused, *"Maybe you can fill up your tube over the bowl and that way if you miss it will go back into the bowl"* (Ob 3). While the child she was suggesting this to did not try this approach, a few minutes later when Beth was ready to fill up her tube, she moved herself around the table to the bowl and rice and held her tube over it while filling up (Ob 4). Table 4.21 lists the place elements that were observed during the described narrative above.

Table 4.21

Place elements observed during DIY Shakers #1

PLACE					
Resources		**Communication**		**Socio-emotional climate**	
Intentional provocations	Not observed	Intentional learning conversations	Ob 2, 3	Stress and pressure free environment	Ob 1, 2
Stimulating materials	Ob 1	Hearing and valuing children's ideas	Ob 3	Non-prescriptive	Not observed
Adequate materials for everyone	Ob 1	Open inquiring questioning	Ob 3	Non-judgemental	Ob 1, 2
Time for creative exploration	Ob 1	Facilitating dialogic conversations	Not observed	Allowed to make mistakes	Ob 1, 3, 4

TYPES OF COMMUNICATION				
Adult-adult	**Children-only**	**Dialogic**	**None on screen**	**Scitech-only**
Not observed	Not observed	Ob 3	Ob 1	Ob 2

Table 4.21 illustrates how the children followed a design brief to create a maker shaker using materials provided by Scitech. They had adequate time and materials and were allowed to experiment and make mistakes as they completed their designs. Milly was observed engaging in intentional learning conversations, questioning, and assisting the children in reflecting on their design process. The children communicated with Milly on the screen, as well as with one another in the classroom. Table 4.22 lists the process characteristics that were observed during the described narrative above.

Table 4.22

Process characteristics observed during DIY Shakers #2

PROCESS					
Agency	**Being Curious**	**Connecting**	**Daring**	**Experimenting**	**Focus**
Ob 1, 2, 4	Ob 2, 4	Not observed	Ob 2, 4	Ob 4	Ob 1, 2
CREATIVE MOMENTS					
Experimenting	**Making**	**Problem-solving**	**Predicting**		
Ob 4	Ob 1, 2, 4	Ob 3, 4	Not observed		

The children were observed demonstrating agency in terms of their maker shaker design, as well as the material (rice or pasta) that they put inside their shaker. They were observed being curious, daring, experimenting, and focused as they completed this activity. The children were observed in this episode experimenting and problem-solving how to best transfer the rice into their shakers.

4.5.10 *DIY Shakers* #2

DIY Shakers was the fourth STEM school-based workshop the children participated in with Milly. Figure 4.14 shows Beth talking to Milly.

Figure 4.14

Beth sharing her maker shaker solution with Milly

Figure 4.14 captures the moment Beth walked over to the AV screen so she could share with Milly a solution she had to a problem. Although faces have been blurred for privacy, Milly smiles encouragingly as she listens to Beth describe how she will colour white pipe cleaners pink. The other children continued working on their maker shakers while this conversation occurs.

Narrative 10: *DIY Shakers #2*

While the researcher helped Beth tie elastic bands around her tube, she asked whether there were any pink pipe cleaners. When told that there were only white, Beth shared an idea with the researcher. *"That's a really good idea Beth, did you hear that, Milly?"* Beth made her way to the AV screen to share her idea directly with Milly, *"I want different colours* [of pipe cleaner] *so at the end I'm going to colour it pink."* Milly nodded and smiled, responding *"oh very nice, that's a good way of solving that problem! Good job, Beth*" (Ob 1). For the next fifteen minutes, Beth worked quietly, concentrating on her design (Ob 2). There were several distractions around her, for instance Jett and another child were shaking their maker shakers quite loudly and Milly was talking to others about their progress. However, Beth was not distracted. She was the last one in the group to finish her maker shaker design. *"I made a bunny rabbit"* she announced broadly to the room, holding up her tube (Ob 3). *"A bunny rabbit, that's really cool"* Milly said, looking around the room to work out which child had made the announcement. Table 4.23 lists the place elements that were observed during the described narrative above.

Table 4.23

Place elements observed during DIY Shakers #2

PLACE					
Resources		**Communication**		**Socio-emotional climate**	
Intentional provocations	Not observed	Intentional learning conversations	Not observed	Stress and pressure free environment	Ob 1, 3
Stimulating materials	Ob 1	Hearing and valuing children's ideas	Ob 1, 3	Non-prescriptive	Not observed
Adequate materials for everyone	Ob 1	Open inquiring questioning	Not observed	Non-judgemental	Ob 1, 3
Time for creative exploration	Ob 2	Facilitating dialogic conversations	Ob 1	Allowed to make mistakes	Ob 1, 2

TYPES OF COMMUNICATION				
Adult-adult	**Children-only**	**Dialogic**	**None on screen**	**Scitech-only**
Not observed	Not observed	Ob 1	Ob 2	Not observed

Table 4.23 illustrates how Milly engaged with the children while they were undertaking their maker shaker activity. Specifically, it shows Milly listening to Beth's ideas and engaging in dialogic conversation with her. Beth was allowed to

explore and experiment in a stress and pressure free environment. Table 4.24 lists the process characteristics that were observed during the described narrative above.

Table 4.24

Process characteristics observed during DIY Shakers #2

PROCESS					
Agency	**Being Curious**	**Connecting**	**Daring**	**Experimenting**	**Focus**
Ob 1, 2, 3	Ob 1	Ob 1, 3	Ob 1, 2	Ob 1, 2	Ob 2

CREATIVE MOMENTS			
Experimenting	**Making**	**Problem-solving**	**Predicting**
Not observed	Ob 1, 2, 3	Ob 1	Not observed

Table 4.24 illustrates how all creative processes were observed during this episode. Specifically, Beth had agency over the design of her shaker and drew upon her existing knowledge of bunny rabbits and how a pipe cleaner could resemble their fluffy tail. She was focused as she experimented with this technique and was daring in giving this idea a go. She was seen problem-solving while making her maker shaker.

4.5.11 *Quiet as a Mouse* puppet show

Quiet as a Mouse was a thirty-minute interactive puppet show that involved children using their own maker shakers and testing instruments to help a music-loving mouse, Racket, placate his sound sensitive neighbour, Melody the cat. The show was delivered by Milly from the Scitech theatre in Perth. This was the final school-based session. Figure 4.15 shows the set reveal of Racket's house.

Figure 4.15

Children enjoying the puppet show experience

Figure 4.15 captures the moment the children see Racket's house for the first time. Although faces have been blurred for privacy, the children's eyes are fixated on the AV screen, and their looks of wonder, including open mouths and hands over mouths, as the camera zoomed out to suddenly reveal the whole set.

Narrative 11: *Quiet as a Mouse* puppet show

The class was sitting on the mat facing the AV screen, ready for the *Quiet as a Mouse* puppet show to start. The Scitech camera framed Milly in the centre of the screen with a dark background behind her. *"We're here to visit our friend Racket…"* Millys explained, *"he's very small…we are going to have to use our imaginations to shrink down to size*." Some of the children fidgeted with their maker shakers while Milly spoke, however Beth sat still with her hands in her lap, eyes on the screen (Ob 1). *"For us to shrink down, let's turn on our imaginations. Everyone it's time to get your hand and put it on your imagination switch* [places hand on side of her head] *and let's click it on the count of three…"* the children followed along with Milly, who went on to say, *"Now we need to find our shrinking button. Mine is on my shoulder. Everyone, put your finger on your shrinking button, wherever it is…"* Beth put her finger back on the side of her head, while Milly counted them down and they all pretended to switch on their buttons (Ob 2). Milly held up a normal-sized shirt button to show that they were still life-size (Ob 3). She talked them through the 'shrinking process,' which involved the children closing their eyes and imagining that they are shrinking. Each time the children closed their eyes, Milly quickly grabbed a larger prop button. On the third attempt, the button was almost as large as Milly, representing that she and the class were now as small as mice. Beth had closed her eyes each time and joined in with her classmates in gasping and shrieking in amazement as they saw the bigger buttons. When the camera zoomed out to show the full set of Racket's house, Beth placed her hand over her mouth in a 'wow' moment. She even clapped. Milly offered the children time to look at the set and share with the child next to them some of the props they could see (Ob 4). Following this, Milly banged on one of Racket's drums, only for a loud *meow* noise to be heard, along with a giant eye appearing through a peep hole at the back of the set. Beth gave a little jump, covered her mouth, and turned around to look at a friend in amazement, before looking back at the AV screen with a smile on her face. Table 4.25 lists the place elements that were observed during the described narrative above.

Table 4.25

Place elements observed during Quiet as a Mouse puppet show

PLACE					
Resources		**Communication**		**SE climate**	
Intentional provocations	Not observed	Intentional learning conversations	Not observed	Stress and pressure free environment	Ob 2
Stimulating materials	Ob 3	Hearing and valuing children's ideas	Not observed	Non-prescriptive	Not observed
Adequate materials for everyone	Not observed	Open inquiring questioning	Not observed	Non-judgemental	Ob 2
Time for creative exploration	Ob 4	Facilitating dialogic conversations	Not observed	Allowed to make mistakes	Not observed

TYPES OF COMMUNICATION				
Adult-adult	**Children-only**	**Dialogic**	**None on screen**	**Scitech-only**
Not observed	Ob 4	No observed	Not observed	Ob 1, 2

Table 4.25 illustrates how the children did not engage with hands-on materials during this part of the *Quiet as a Mouse* puppet show but were observing stimulating materials on the AV screen. Further, communication elements were not observed. These findings can all be attributed to the nature of the show, which was a performance rather than an interactive workshop. The children were in a pressure-free environment, given the space to select where their own 'imagination buttons' were located on their bodies. Table 4.26 lists the process characteristics that were observed during the described narrative above.

Table 4.26

Process characteristics observed during Quiet as a Mouse puppet show

PROCESS					
Agency	**Being Curious**	**Connecting**	**Daring**	**Experimenting**	**Focus**
Ob 2	Ob 4	Ob 4	Not observed	Not observed	Ob 1, 4

CREATIVE MOMENTS			
Experimenting	**Making**	**Problem-solving**	**Predicting**
Not observed	Not observed	Ob 2	Not observed

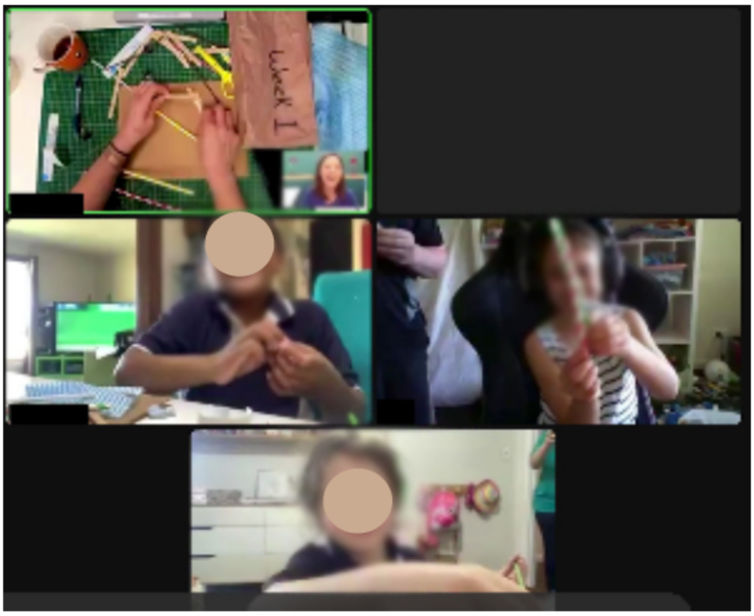
The children were given opportunities to choose where their own imagination buttons were located and appeared engaged and focused on the unfolding events of the show. During this episode, only the creative moment of problem-solving was observed. This finding could be attributed to the nature of this part of the show, which was a performance rather than an interactive workshop.

4.5.12 *Wind Houses* #1

Wind Houses was the first of four afterschool STEM club sessions, facilitated by Tahlia. Inspired by *The Three Little Pigs,* children built a house using provided materials that could withstand the force of wind. Figure 4.16 captures a moment where the children and Tahlia were engaging in a light-hearted conversation together.

Figure 4.16

Jett joking around and receiving encouragement from others



Although the faces have been blurred for privacy, this picture shows the smiles and laughter on the children and Tahlia's faces as they joke around over Zoom. Their hands are still busy working on their projects as they look at one another on screen. Tahlia's set-up allows the children to see both her face and her hands as she works on the same design challenge as the children.

Narrative 12: *Wind Houses #1*

The children were eagerly sifting their packs of materials, excited by what they found. *"I have Blu Tack!"* Beth exclaimed, holding it up to the screen (Ob 1). Jett started rummaging around until he found his own Blu Tack. Tahlia was engaging the children in a conversation, prompting them with questions like, *"What kind of things might help your house from blowing down?"* and *"How would you put them together I wonder?"* (Ob 2). The children were focused on manipulating their various materials (Ob 3). *"I think I have too much Blu Tack"* Beth said to which Jett replied, *"I don't have that much Blu Tack."* Immediately, Beth joked *"Here, take some of my Blu Tack!"* and held some Blu Tack up to her camera (Ob 4). The others all laughed, and Tahlia commented *"Wouldn't that be cool."* Tahlia then re-directed the conversation back to their buildings. Apparently out of the blue, Beth began to sing a tune and Chloe immediately joined in, both smiling as they did so. *"Please no!"* Jett joked. While all this unfolded, the children continued to use their materials to work on their house designs. Tahlia again attempted to re-direct their focus by reminding them how much time they had left (Ob 5). *"I'm restarting, I can't do this…it's hard"* Jett said, putting his straws down and fiddling with the Blu Tack. *"You can do it Jett"* Chloe said. *"Yeah, I like that positivity, I think you can do it"* Tahlia said. Table 4.27 lists the place elements that were observed during the described narrative above.

Table 4.27

Place elements during Wind Houses #1

PLACE					
Resources		**Communication**		**Socio-emotional climate**	
Intentional provocations	Ob 1	Intentional learning conversations	Ob 2	Stress and pressure free environment	Ob 1, 2
Stimulating materials	Ob 1	Hearing and valuing children's ideas	Ob 2	Non-prescriptive	Ob 1
Adequate materials for everyone	Ob 1	Open inquiring questioning	Ob 2	Non-judgemental	Ob 2
Time for creative exploration	Ob 1, 3	Facilitating dialogic conversations	Ob 2	Allowed to make mistakes	Ob 2, 3

TYPES OF COMMUNICATION				
Adult-adult	**Children-only**	**Dialogic**	**None on screen**	**Scitech-only**
Not observed	Ob 4	Ob 2	Not observed	Ob 5

Table 4.27 illustrates how all elements of place were observed during this episode. The children each received their own pack of materials and given the duration of the session to work on their open-ended design challenge. Throughout, Tahlia was observed engaging in a range of communication with the children, maintaining a

positive socio-emotional climate. Specifically, Chloe and Tahlia are seen encouraging Jett when he comments on the task being challenging. In this part of the session, no adult-adult communication or quiet time was observed. Table 4.28 lists the process characteristics that were observed during the described narrative above.

Table 4.28

Process characteristics observed during Wind Houses #1

PROCESS					
Agency	**Being Curious**	**Connecting**	**Daring**	**Experimenting**	**Focus**
Ob 3	Ob 1, 2	Ob 2, 4	Ob 3	Ob 3	Ob 3

CREATIVE MOMENTS			
Experimenting	**Making**	**Problem-solving**	**Predicting**
Not observed	Ob 3	Ob 2, 4	Not observed

Table 4.28 illustrates how all creativity processes were observed during this episode. They are engaged in the creative moment of making their wind houses, and Beth is seen playfully solving the problem of Jett having no more Blu Tack.

4.5.13 *Wind Houses* #2

Wind Houses was the first of four afterschool STEM club sessions, facilitated by Tahlia. Figure 4.17 shows Jett not on task as he returns to his working space with a toy bow and arrow.

Figure 4.17

Jett losing focus during the Houses activity

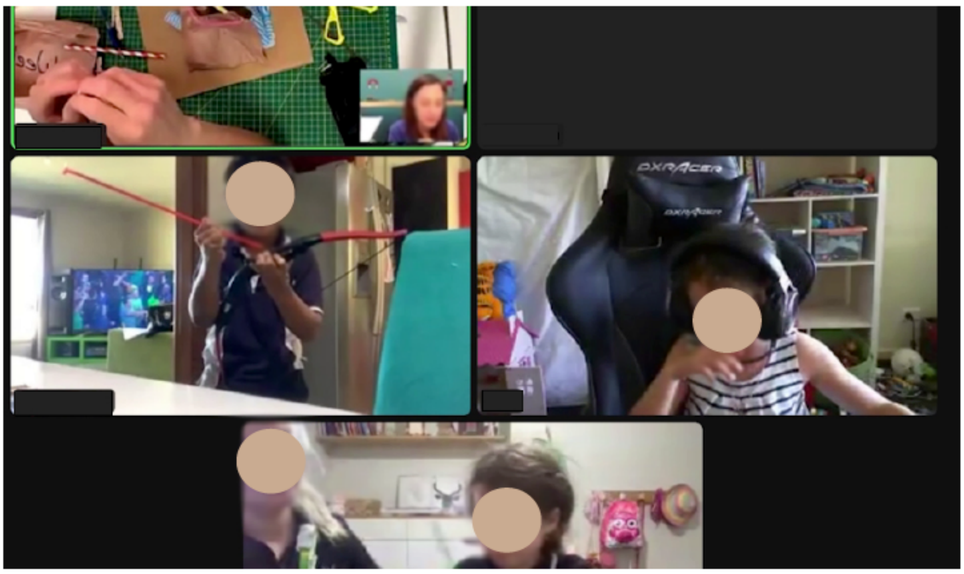


Figure 4.17 highlights the lack of focus on the design challenge Jett was demonstrating at this point in the session. He was returning to his workspace with a toy bow and arrow, while Tahlia asked him to put it away and return to building his house. Meanwhile, the other two children stay focused on their designs.

Narrative 13: *Wind Houses* #2

The children were halfway through their first afterschool STEM club session, working to build a house that can withstand the force of wind. Jett found this task challenging from the start. He held up his construction – a floor with straw wall frames – to show Beth (Ob 1). Seeing this Tahlia asks, *"That's awesome, what else do you need now Jett to stop the wind getting in?*" She suggested he builds some walls and shares the materials she currently using for her walls (Ob 2). Jett appeared off-task, playing with Blu Tack and asking Beth questions. *"Alright, we don't have much longer…"* Tahlia said to re-focus them. *"Ok, I'm now done,*" he said a moment later, holding up a combination of pop sticks he had stuck together that was not related to his house project. *"So, thinking about houses,"* Tahlia said, continuing to work on her own build, *"they need walls and a roof, don't they*?" Jett continued making shapes with his pop sticks, which resulted in Chloe calling out, *"You're suspicious*!" Tahlia attempted to connect this conversation back to the task, *"Which character in the book was the suspicious one?"* to which the three children responded, "*The wolf!"* (Ob 3). By now, Jett had built an arrow out of his popsticks. The other two children appeared unimpressed, pointing out that he was off task. Tahlia directed the children to create a pig out of straw to place inside their house for the wind blowing part of their experiment. Instead of a straw, Jett curled up a white pipe cleaner, *"it doesn't look that good,"* he said showing it to the others, *"but that's my pig."* Then he then abruptly walked into the living room, returning to the dining room table holding a plastic bow and arrow (Ob 8). *"Jett, what are you doing?!"* the other two children exclaimed. *"Jett, you can show me that one later I think*" Tahlia said. At this point, we heard Jett's mum calling out from off-screen, *"Jett, what are you doing?"* He responded, *"Nothing",* and quickly returned to his wind house. *"You have your project manager there helping you out*" Tahlia quipped. He looked encouraged when Tahlia tells them they still had five minutes left. During this time, he said, *"This is hard"* but continued working (Ob 4). When told there were three minutes left, he shared that he was, *"Focusing on my roof."* At this point, he was standing up, leaning over his construction. When he shared that it kept falling down, Tahlia asked if there was any way he could make it stronger before sharing how she liked to use pipe cleaners in her constructions (Ob 5). At the end of the five minutes, Tahlia conducted an experiment on her house design to see how well it could withstand wind force using a hair dryer. During the past five minutes she had quickly built a second house design, with a loose roof that would blow off when she tested it. Jett was engaged in making predictions about her house and observed what happens (Ob 6). Following this she asked, *"Can I have a look at yours, Jett?"* He said he needed another minute to finish adding some Chux, and then after another prompt he showed his design and then began experimenting. He used his mouth to blow some wind at his house, smiling at the camera and saying, "*Mine didn't fall down.*" (Ob 7). Table 4.29 lists the place elements that were observed during the described narrative above.

Table 4.29

Place elements observed in Wind Houses #2

PLACE					
Resources		**Communication**		**SE climate**	
Intentional provocations	Ob 1	Intentional learning conversations	Ob 2, 3, 5	Stress and pressure free environment	Ob 2
Stimulating materials	Ob 1	Hearing and valuing children's ideas	Ob 3	Non-prescriptive	Ob 1
Adequate materials for everyone	Ob 1	Open inquiring questioning	Ob 2, 5	Non-judgemental	Ob 2, 6
Time for creative exploration	Ob 1, 4	Facilitating dialogic conversations	Ob 3, 5	Allowed to make mistakes	Ob 1, 7

TYPES OF COMMUNICATION				
Adult-adult	**Children-only**	**Dialogic**	**None on screen**	**Scitech-only**
Not observed	Ob 1	Ob 3, 5, 6	Ob 4	Ob 2

Table 4.29 illustrates how all elements of place were observed during this episode. Throughout the episode, Tahlia was observed engaging Jett with a range of communication strategies to re-focus him on the design challenge. In doing this, she maintained a calm and pleasant tone, free of pressure and judgement. Table 4.30 lists the process characteristics that were observed during the described narrative above.

Table 4.30

Process characteristics observed in Wind Houses #2

PROCESS					
Agency	**Being Curious**	**Connecting**	**Daring**	**Experimenting**	**Focus**
Ob 1, 4	Ob 2	Ob 1, 3	Ob 4, 7	Ob 7	Ob 1, 4, 7
CREATIVE MOMENTS					
Experimenting	**Making**	**Problem-solving**	**Predicting**		
Ob 7	Ob 1, 4	Ob 2, 5	Ob 6		

Table 4.30 illustrates how all creativity processes were observed during this episode. However, focus was a process which appeared only towards the end of the episode for Jett, with his behaviour being off task for the first part. During this episode, the children were observed engaging in all four types of creative moments as they worked on building their houses.

4.5.14 *Egg Drop* #1

Egg Drop was the second session of the afterschool STEM club, facilitated by Tahlia. Children built an egg holder, using provided materials, to protect an egg when it was dropped from a height. Figure 4.18 shows the moment just before Jett released his egg into his first design.

Figure 4.18

Children working on Egg Drop challenge

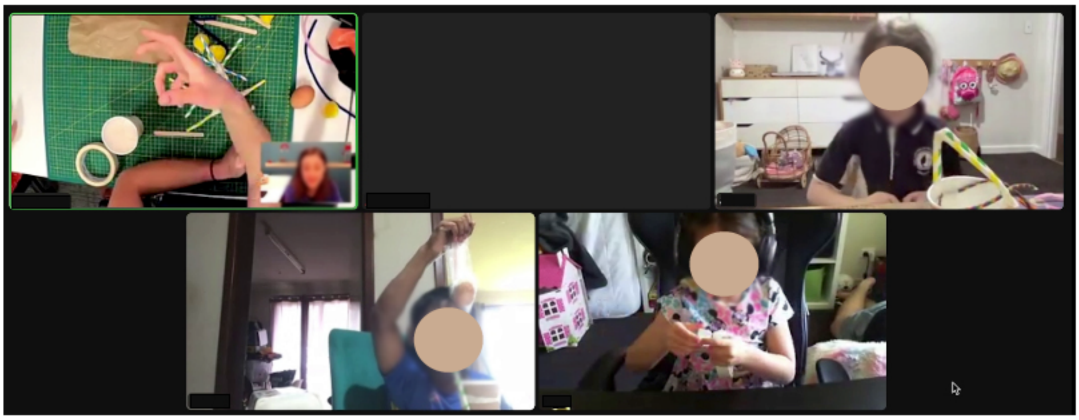


Figure 4.18 captures Jett just before he experimented with his first egg holder design. Tahlia was counting him down, while Beth looked on with interest. Chloe continued to work on her own build but had looked up intermittently at her screen to watch Jett prepare for his drop.

Narrative 14: *Egg Drop* #1

"Tahlia, I am finished" Jett announced after almost fifteen minutes of designing his egg drop construction. *"You're finished? That's awesome…We're all going to test them together. Or should we test them one by one, what do you think?" "One by one,"* the children responded (Ob 1). Tahlia agreed to give the girls one more minute to finish, counting down the last ten seconds (Ob 2). *"Ok, Jett so you've got yours ready."* She prompted him to test it, observing that his construction involved him dropping the egg into a cushioned cup. He stood up on his chair in order to gain the required height and dropped it down into the cup (Ob 3). *"Woah!"* he exclaimed, grabbing it and holding it up so the others could see that it did not break. Beth and Chloe continued to work on their constructions but glanced up quickly while he was testing (Ob 4). Tahlia congratulated him, and then asked some questions, prompting him to reflect on the design, "*How would this design work if he was dropping it from the top floor of a building?"* (Ob 5). Chloe tested her egg next, having constructed a similar design to Jett's in which the egg would fall onto a cup with padding around it. After speaking with Beth for a minute about her progress, Tahlia returned her attention to Jett, *"How do you think you could improve your design?"* she asked him. *"By making it more bigger,"* he responded (Ob 6). *"What I want you guys to do is build around the egg"* Tahlia said, demonstrating with her own materials. *"I don't want you to drop it into anything, there can't be anything on the table. So, you want to try and slow it down, you could make a parachute or cover it in something soft. Do you think you could do that?"* The children spent the remaining ten minutes adapting their designs, trying new approaches, and testing them (Ob 7). Table 4.31 lists the place elements that were observed during the described narrative above.

Table 4.31

Place elements observed during Egg Drop #1

PLACE					
Resources		**Communication**		**SE climate**	
Intentional provocations	Ob 3	Intentional learning conversations	Ob 5	Stress and pressure free environment	Ob 1, 2
Stimulating materials	Ob 3	Hearing and valuing children's ideas	Ob 1, 2	Non-prescriptive	Not observed
Adequate materials for everyone	Ob 3	Open inquiring questioning	Ob 5	Non-judgemental	Ob 1, 3
Time for creative exploration	Ob 2, 7	Facilitating dialogic conversations	Ob 5	Allowed to make mistakes	Ob 3
TYPES OF COMMUNICATION					
Adult-adult	**Children-only**	**Dialogic**	**None on screen**	**Scitech-only**	
Not observed	Not observed	Ob 1, 5	Ob 4, 7	Ob 2	

Table 4.31 illustrates how all but one of the place elements were observed. Tahlia was seen providing prescriptive instructions to the children to attempt a re-design of their egg baskets so that they built around the egg. Each child worked with materials provided to them by Scitech, and they had sufficient time throughout the session to work on their task. The children and Tahlia engaged in a range of communication throughout. Table 4.32 lists the process characteristics that were observed during the described narrative above.

Table 4.32

Process characteristics observed during Egg Drop #1

PROCESS					
Agency	**Being Curious**	**Connecting**	**Daring**	**Experimenting**	**Focus**
Ob 1	Ob 5	Ob 6	Ob 3, 7	Ob 3, 7	Ob 4, 7
CREATIVE MOMENTS					
Experimenting	**Making**	**Problem-solving**	**Predicting**		
Ob 3, 7	Ob 2, 7	Ob 5, 7	Not observed		

All creativity processes were observed. The children had agency over their designs, and how they went about completing their re-design within the parameters Tahlia provided. While the focus of the task was on the creative moment of making an egg basket, Chloe and Jett were observed experimenting with their first designs, before engaging in a problem-solving process to consider new designs that went around the egg. No predicting was observed prior to the children testing their designs.

4.5.15 *Egg Drop* #2

Egg Drop was the second session of the afterschool STEM club, facilitated by Tahlia. Figure 4.19 shows Tahlia counting down Beth to drop her egg.

Figure 4.19

Beth preparing to drop her egg while Tahlia counts her down

Figure 4.19 captures Tahlia as she completed a countdown to help Beth test her egg holder design. Beth's mum is visible at the door of the playroom, watching in support.

Narrative 15: *Egg Drop* #2

It was coming to the end of the *Egg Drop* session, and both Jett and Chloe have tested their constructions twice, each having a success and a 'failure' (cracked egg) (Ob 1). While Chloe was finishing her second experiment, Beth was moving away from the desk to prepare to drop the design. Seeing her standing up and holding out her construction, Tahlia said, "*Alright, Beth is ready! Are you ready to drop it?"* Beth responded, *"I don't know…I'm very scared."* Tahlia said reassuringly, *"I think you've done an awesome job"* to which Beth continued quickly, *"I don't want my egg to break, because then* [if it doesn't break] *I could take it out and make egg on toast"* and promptly sat back down in front of the laptop. *"Ok, we all need to count down,"* Tahlia said to the other two children, *"because Beth is going to be super brave and drop her egg in five seconds, let's all count down…"* she held her fingers up to the screen and Jett joined in (Ob 2). Beth moved back to the open part of her room; her mum was in the room watching as well. She dropped the egg with enthusiasm and a bit of force. *"Is it broken? Who thinks it broke?"* Tahlia asked the others while Beth checked. She looked closely at the egg with her mum and then brought it up close to the screen to show the others the crack (Ob 3). *"Oh, a little crack. Hey, can I get you all to give yourselves a big clap because that was a tricky challenge even for adults and teenagers to do,"* Tahlia said before wrapping up the session. *"If there's one material you could use to build this, what would you use?" "Pom poms,"* Beth said (Ob 4). Table 4.33 lists the place elements that were observed during the described narrative above.

Table 4.33

Place elements observed in Egg Drop #2

PLACE					
Resources		**Communication**		**Socio-emotional climate**	
Intentional provocations	Ob 1	Intentional learning conversations	Ob 3, 4	Stress and pressure free environment	Ob 1, 2, 3
Stimulating materials	Ob 1	Hearing and valuing children's ideas	Ob 2	Non-prescriptive	Ob 1
Adequate materials for everyone	Ob 1	Open inquiring questioning	Ob 4	Non-judgemental	Ob 1, 2
Time for creative exploration	Ob 1	Facilitating dialogic conversations	Ob 3, 4	Allowed to make mistakes	Ob 1, 2, 3

TYPES OF COMMUNICATION				
Adult-adult	**Children-only**	**Dialogic**	**None on screen**	**Scitech-only**
Not observed	Not observed	Ob 4	Not observed	Ob 2

Table 4.33 illustrates how all place elements were observed during this episode. The children engaged in dialogic conversation with Tahlia, who always spoke directly to the children. Specifically, Beth was encouraged to test her design, and Tahlia and the others were seen supporting and encouraging her, even when her egg broke. Table 4.34 lists the process characteristics that were observed during the described narrative above.

Table 4.34

Process characteristics observed during Egg Drop #2

PROCESS					
Agency	**Being Curious**	**Connecting**	**Daring**	**Experimenting**	**Focus**
Ob 1	Ob 1, 3, 4	Ob 1, 4	Ob 1, 3	Ob 1, 2	Ob 1

CREATIVE MOMENTS			
Experimenting	**Making**	**Problem-solving**	**Predicting**
Ob 1, 2	Ob 1	Ob 4	Ob 3

All creative processes were observed during this episode. Prior to Beth testing her egg design, Tahlia encouraged the children to predict whether the egg would crack or not.

4.5.16 *Ball Run* #1

Ball Run was the third session of the afterschool STEM club, facilitated by Tahlia. Inspired by Rube Goldberg machines, children used provided materials to construct their own simple ball run. Figure 4.20 shows Beth and her mum at the start of the session as they explored the items in the pack provided by Scitech.

Figure 4.20

Beth and her mum exploring ball run materials

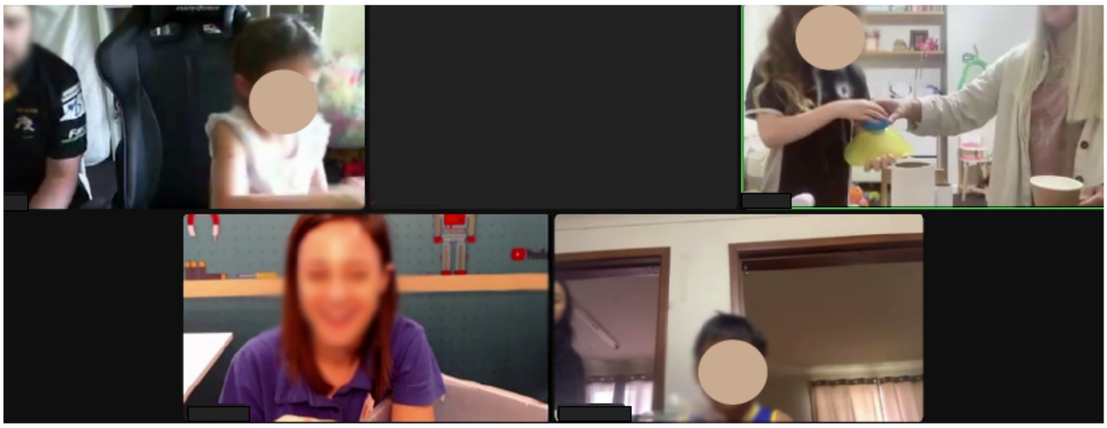


Figure 4.20 captures Beth and her mum collaborating, as Beth experimented with fitting the blue ball through the hole of the yellow cone. Tahlia had strategically provided the children with quiet time to explore these materials. Although the faces are blurred for privacy, Tahlia was actively watching and smiling encouragingly as she watched Beth and her mum.

Narrative 16: *Ball Run* #1

The children had just opened their packs and were excitedly sifting through the materials (Ob 1). Beth's mum knelt on the ground next to her, observing. As Beth pulled materials out of her pack, she took her time holding them up and staring at them, apparently considering how they might be used in her ball run. She then shared some ideas with her mum about the design (Ob 2). Suddenly, she gasped and leant forward to pick up her cone before turning back to her mum to say, *"Maybe I could like, put the ball inside…"* Her mum as this point reached over to grab a ball and placed it where Beth is pointing, which prompted a quick experiment. This experiment helped Beth realise that the ball is too big to fit through the cone (Ob 3). She located a smaller ball and tested it out, *"I have a great idea of what to do!"* she said enthusiastically, before her mum pointed out that Tahlia had been trying to get her attention (Ob 4).

Table 4.35 lists the place elements that were observed during the described narrative above.

Table 4.35

Place elements observed during Ball Run #1

PLACE					
Resources		**Communication**		**Socio-emotional climate**	
Intentional provocations	Ob 1	Intentional learning conversations	Not observed	Stress and pressure free environment	Ob 1, 2
Stimulating materials	Ob 1	Hearing and valuing children's ideas	Not observed	Non-prescriptive	Ob 1
Adequate materials for everyone	Ob 1	Open inquiring questioning	Not observed	Non-judgemental	Ob 2
Time for creative exploration	Ob 1	Facilitating dialogic conversations	Not observed	Allowed to make mistakes	Ob 3

TYPES OF COMMUNICATION				
Adult-adult	**Children-only**	**Dialogic**	**None on screen**	**Scitech-only**
Not observed	Not observed	Not observed	Ob 1, 2	Ob 4

Table 4.35 illustrates how the children engaged in off-screen communication during this episode. No instances of conversations or questioning were observed between Tahlia and the children. This finding can be attributed to Tahlia intentionally giving the children time to explore what is in their packs and share ideas with their parents.

Table 4.36 lists the process characteristics that were observed during the described narrative above.

Table 4.36

Process characteristics observed during Ball Run #1

PROCESS					
Agency	**Being Curious**	**Connecting**	**Daring**	**Experimenting**	**Focus**
Ob 1, 2	Ob 1, 2, 3	Ob 2	Ob 2	Ob 3	Ob 1, 3

CREATIVE MOMENTS			
Experimenting	**Making**	**Problem-solving**	**Predicting**
Ob 3	Ob 1	Ob 2	Not observed

All creative processes were observed during this episode. Specifically, Beth was seen planning and experimenting with the items in her pack to see how they might work together to create a ball run. She engaged in problem-solving to work out which ball might work best with the cone.

4.5.17 *Ball Run #2*

Ball Run was the third session of the afterschool STEM club, facilitated by Tahlia. Figure 4.21 shows Chloe sharing a design idea with her dad.

Figure 4.21

Chloe using quiet time to plan her design with her dad

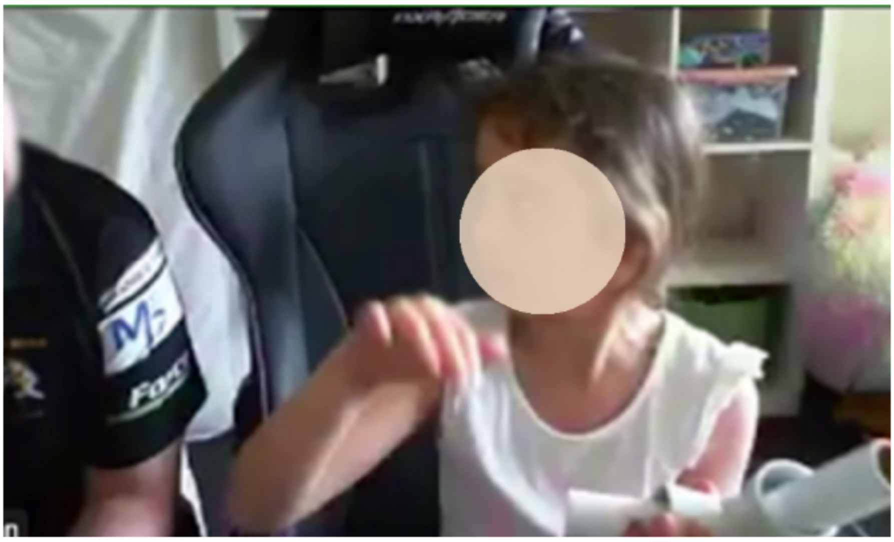


Figure 4.21 captures Chloe as she discussed one of her ball run ideas with her dad. He sat nearby, listening to her ideas as she showed him the different materials in her pack. Her focus was on talking with her dad rather than the others on screen.

Narrative 17: *Ball Run* #2

The children responded enthusiastically to Tahlia's question, "*are you ready to build something awesome!?*" Tahlia had just finished outlining the design brief for the ball run challenge (Ob 1). Tahlia continued, *"I'm going to let you have a think for a bit. I'm going to stay here if you have questions, but for now you can go off and look* [at your materials] *and go ahead!"* Pausing for a moment to think, Chloe reached for some PVC pipes, turning to her dad who sat beside her (Ob 2). She excitedly relayed her plan to him, *"I'm going to take the short ones* [pipes] *so the marble can go through* [gestures]." Her dad responded by suggesting, *"Put a marble in there now and see if it works."* Chloe asked him to help by holding out his hand at one end of the pipe, while she released the marble into the pipe at the other end. *"Nice!"* she whispered with a smile when it worked successfully (Ob 3). She picked up various materials and held them up side-by-side, assessing how they might fit together. During this period of quiet concentration, Jett called out to Chloe, showing her how he was playfully using one of his tubes as a trumpet. She smiled and mimicked him with her own tube, before quickly returning to her construction (Ob 4). Table 4.37 lists the place elements that were observed during the described narrative above.

Table 4.37

Place elements observed in Ball Run #2

PLACE					
Resources		**Communication**		**Socio-emotional climate**	
Intentional provocations	Ob 1	Intentional learning conversations	Not observed	Stress and pressure free environment	Ob 2
Stimulating materials	Ob 2	Hearing and valuing children's ideas	Not observed	Non-prescriptive	Ob 1
Adequate materials for everyone	Ob 2	Open inquiring questioning	Not observed	Non-judgemental	Ob 2, 3
Time for creative exploration	Ob 2	Facilitating dialogic conversations	Not observed	Allowed to make mistakes	Ob 3

TYPES OF COMMUNICATION				
Adult-adult	**Children-only**	**Dialogic**	**None on screen**	**Scitech-only**
Not observed	Ob 4	Not observed	Ob 2, 3	Ob 1

Table 4.37 illustrates how the children engaged in off-screen communication during this episode. No instances of conversations or questioning were observed between Tahlia and the children. This finding is attributed to Tahlia intentionally giving the children time to explore what is in their packs and share ideas with their parents. Table 4.38 lists the process characteristics that were observed during the described narrative above.

Table 4.38

Process characteristics observed in Ball Run #2

PROCESS					
Agency	**Being Curious**	**Connecting**	**Daring**	**Experimenting**	**Focus**
Ob 2, 3	Ob 2, 3	Ob 2	Ob 3	Ob 3	Ob 2, 4

CREATIVE MOMENTS			
Experimenting	**Making**	**Problem-solving**	**Predicting**
Ob 3	Ob 2, 4	Not observed	Not observed

All creative processes were observed during this episode. Specifically, Chloe was observed planning and experimenting with the items in her pack to see how they might work together to create a ball run.

4.5.18 *Ball Run* #3

Ball Run was the third session of the afterschool STEM club, facilitated by Tahlia. Inspired by Rube Goldberg machines, children used provided materials to construct their own simple ball run. Figure 4.22 captures part of a conversation between Beth and Tahlia during the building phase of the session.

Figure 4.22

Tahlia encouraging Beth during Ball Run challenge

Figure 4.22 shows Tahlia and Beth having a conversation about the progress of her ball run. Tahlia had stopped working on her own ball run and was seen leaning in close to the camera, showing a level of attention and care towards Beth. As Tahlia shared words of encouragement, Beth continued to work on her build quietly, she was pictured here with her eyes on her construction. She had been intermittently looking up at the screen as she listened to Tahlia. The other two children continued to work on their own projects while this conversation occurred.

Narrative 18: *Ball Run* #3

After about ten minutes of working quietly on their ball runs, Jett asked, *"Beth, how are you going?"* and she responded, "*Not good.*" (Ob 1). She 'was busy with her hands, cutting and sticking things together, but had shown frustration that one part of her build was not working. *"Aww, why not good, Beth?"* Tahlia asked, leaning in close to her camera to smile encouragingly at Beth. *"Because it's just not turning out right,"* Beth said. To that, Tahlia said, *"That's okay, did you see mine? Mine all fell off the desk before! It doesn't have to be perfect straight away, you can keep working on it and making it better. It's very rare these things work straight away. You saw the video* [of the professional ball run] *they would have tried that probably about a hundred times before they got it right*" (Ob 2). At the point Tahlia began talking about the professional ball run, Beth stopped working, and was listening intently.

There was silence, and Beth appeared to be thinking about what had been said. Then, she called out, *"I have a great idea!"* and quickly reached for some sticky tape (Ob 3). About two minutes later, as Jett adjusted his iPad camera to show the others his full ball run, Beth observed and then said, *"Thank you, Jett! You gave me a great idea,"* and reached for a cone. Table 4.39 lists the place elements that were observed during the described narrative above.

Table 4.39

Place elements observed during Ball Run #3

PLACE					
Resources		**Communication**		**SE climate**	
Intentional provocations	Ob 1	Intentional learning conversations	Not observed	Stress and pressure free environment	Ob 2
Stimulating materials	Ob 1	Hearing and valuing children's ideas	Not observed	Non-prescriptive	Ob 1, 2
Adequate materials for everyone	Ob 1	Open inquiring questioning	Not observed	Non-judgemental	Ob 2
Time for creative exploration	Ob 1	Facilitating dialogic conversations	Ob 2	Allowed to make mistakes	Ob 2

TYPES OF COMMUNICATION				
Adult-adult	**Children-only**	**Dialogic**	**None on screen**	**Scitech-only**
Not observed	Ob 1	Ob 2	Ob 3	Not observed

Table 4.39 illustrates how most of the place elements were observed during this episode. Specifically, Tahlia was seen communicating and encouraging Beth as she struggled with parts of the challenge. The focus of their communication was not so much on 'intentional learning' but rather on the process and resilience required in design challenges. Table 4.40 lists the process characteristics that were observed during the described narrative above.

Table 4.40

Process characteristics observed during Ball Run #3

PROCESS					
Agency	**Being Curious**	**Connecting**	**Daring**	**Experimenting**	**Focus**
Ob 3	Ob 1, 3	Ob 3	Ob 1, 3	Ob 3	Ob 1, 3

CREATIVE MOMENTS			
Experimenting	**Making**	**Problem-solving**	**Predicting**
Not observed	Ob 1, 3	Ob 3	Not observed

All creative processes were observed during this episode. Beth was seen displaying elements of daring as she persisted through her design challenge. While making her ball run, she considered how to fix problems she was encountering.

4.5.19 *Floating Boats* #1

Floating Boats was the fourth session of the afterschool STEM club, facilitated by Tahlia. Children used provided materials to construct a boat that could float while carrying cargo. Figure 4.23 shows Jett experimenting with how much weight his boat could hold.

Figure 4.23

Jett successfully testing his boats with weights in it

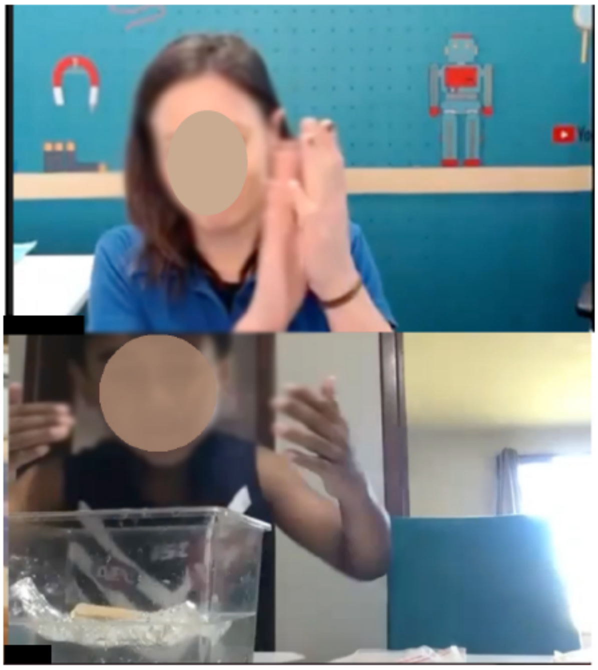


Figure 4.23 captures a moment of celebration for Jett, as his boat successfully held bolts and popsticks while floating. He was mid-celebratory dance while Tahlia watched and clapped on encouragingly.

Narrative 19: *Floating Boats* #1

"Jett, I love your resilience with this. It's really awesome to see you keep trying different things. I think you're a very good boat builder!" (Ob 1). These words were uttered by Tahlia just minutes before a gasp of disbelief filled the room. Jett waved

his arms around in a victory dance, as he bobbed down close to a bucket of water in which his boat was successfully floating. He turned to his mum, who was sitting nearby off-screen and gave her a smile. After half an hour of patiently testing and refining his design, his canoe-shaped boat had successfully met the design brief of being able to float while holding cargo (Ob 2). *"Three pop sticks and two bolts!"* he exclaimed proudly, while Tahlia clapped on in celebration. Although Scitech had provided Jett with a range of construction materials, he chose just the al foil to work with (Ob 3). Table 4.41 lists the place elements that were observed during the described narrative above.

Table 4.41

Place elements observed in Floating Boats #1

PLACE					
Resources		**Communication**		**SE climate**	
Intentional provocations	Ob 1	Intentional learning conversations	Not observed	Stress and pressure free environment	Ob 1
Stimulating materials	Ob 2	Hearing and valuing children's ideas	Not observed	Non-prescriptive	Ob 1, 3
Adequate materials for everyone	Ob 2	Open inquiring questioning	Not observed	Non-judgemental	Ob 1, 3
Time for creative exploration	Ob 2	Facilitating dialogic conversations	Ob 1	Allowed to make mistakes	Ob 1

TYPES OF COMMUNICATION				
Adult-adult	**Children-only**	**Dialogic**	**None on screen**	**Scitech-only**
Not observed	Not observed	Ob 1	Ob 2	Not observed

Many place elements were observed during this episode. Specifically, Tahlia was observed encouraging and communicating with Jett as he successfully tested his boat design. Jett appeared to have adequate time for creative exploration, with it having taken until almost the end of the session for him to have this level of success. Table 4.42 lists the process characteristics that were observed during the described narrative above.

Table 4.42

Process characteristics observed during Floating Boats #1

PROCESS					
Agency	**Being Curious**	**Connecting**	**Daring**	**Experimenting**	**Focus**
Ob 2, 3	Ob 2, 3	Ob 2, 3	Ob 2, 3	Ob 2	Ob 2

CREATIVE MOMENTS			
Experimenting	**Making**	**Problem-solving**	**Predicting**
Ob 2	Ob 1, 3	Not observed	Not observed

All creative processes were observed during this episode as Jett demonstrated agency, focus, and resilience in the development of his boat design. He was seen experimenting to test his boat construction, although no predictions were made prior to this experiment.

4.5.20 *Floating Boats* #2

Floating Boats was the fourth session of the afterschool STEM club, facilitated by Tahlia. Figure 4.24 shows Beth testing her boat after converting it to a submarine.

Figure 4.24

Beth testing her boat after converting it to a submarine

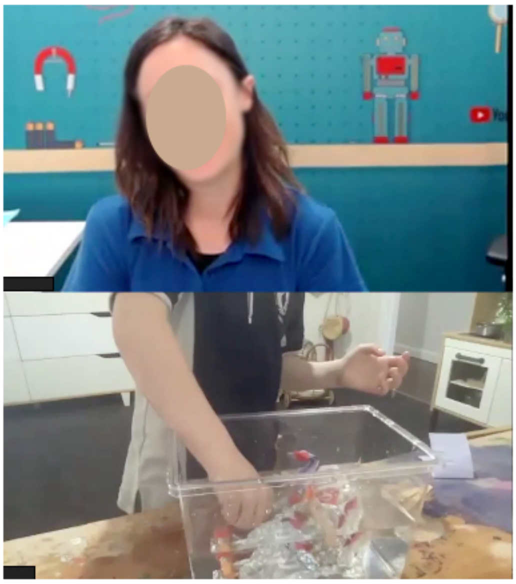


Figure 4.24 captures a final experiment of Beth's in which she had converted her 'failed' boat into a 'successful' submarine. She had tilted her laptop downwards so

the others could see her tub of water. Tahlia watched on, smiling encouragingly at Beth's creativity.

Narrative 20: ***Floating Boats*** **#2**

For the duration of the session, Beth had been concentrating intently on her task to build a boat that could float (Ob 1). Although she was initially hesitant to test it in her tub of water, she put it in once she felt ready. She had mixed success, with the boat both sinking once and floating once (Ob 2). Utilising a range of materials sent to her by Scitech, along with tools from her playroom, she had transformed her boat into a 'unicorn boat' and then a 'swan boat.' It appeared that the additional weight of materials used for the boat has contributed to the boat sinking. Tahlia encouraged Beth to test her boat for a third time, counting her down from three to one. Beth let the boat sit in the water, where it immediately started to tip to one side and fill up with water. *"No, no I'm not ready yet"* she said quickly, grabbing the boat out of the tub. *"That's ok, that's ok, we've tested it"* Tahlia said. "*Pop it back in and let's see if we can add some weights to it."* Beth, busy with her hands, said, *"Nope, it does not float. I need to make some adjustments."* Tahlia observed Beth for a moment before suggesting, *"Maybe there's too much weight on one side, Beth?"* (Ob 3). With Tahlia's encouragement, Beth tested her boat two more times, each time quickly grabbing it out the water as it started to sink. *"I just need to take some plasticine off…*" Tahlia counted her down a third time, but the boat still sank. Beth was eager to keep adjusting the boat design, however Tahlia asked her to put it to one side so she could wrap up the session. Tahlia reflected on Jett's boat design, before turning to Beth. *"Beth, yours was amazing from the get-go. You made a big boat, and it floated really well, but I think maybe if we had a little more time, you might have been able to adjust it, so it floated a little better…and that's just what happens. We try to improve things, and sometimes, it's actually pretty good the first time. I want you to give yourselves a big clap because that was awesome"* (Ob 4). During Tahlia's wrap-up, Beth began quietly working on her boat again. Just as Tahlia was about to say goodbye, Beth smiled at the camera and told her she had turned her boat into a submarine. Tahlia gasped and asked if she wanted to test it. Beth explained, *"You're going to see my submarine sink to the bottom* [of the tub of water] *but this time it won't get any water in it*." Tahlia exclaimed, "*Ooh awesome! What a great addition you've made.*" Beth placed the 'submarine' into the tub of water, and they all watched it slowly sink. *"So, it actually takes time floating to the bottom like a real submarine,"* she explained proudly (Ob 5). Table 4.43 lists the place elements that were observed during the described narrative above.

Table 4.43

Place elements observed during Floating Boats #2

PLACE					
Resources		**Communication**		**SE climate**	
Intentional provocations	Ob 1	Intentional learning conversations	Not observed	Stress and pressure free environment	Ob 1, 2
Stimulating materials	Ob 1	Hearing and valuing children's ideas	Ob 3	Non-prescriptive	Ob 1
Adequate materials for everyone	Ob 1	Open inquiring questioning	Ob 3	Non-judgemental	Ob 1, 2, 4
Time for creative exploration	Ob 1	Facilitating dialogic conversations	Not observed	Allowed to make mistakes	Ob 2

TYPES OF COMMUNICATION				
Adult-adult	**Children-only**	**Dialogic**	**None on screen**	**Scitech-only**
Not observed	Not observed	Ob 3	Not observed	Ob 4

Table 4.43 illustrates how the children were provided with stimulating resources to construct a boat design as well as the encouragement Beth received when choosing to convert her 'failed' boat into a 'successful' submarine. Beth appeared to have adequate time for creative exploration, with it having taken until the end of the session for her to have this success. Table 4.44 lists the process characteristics that were observed during the described narrative above.

Table 4.44

Process characteristics observed during Floating Boats #2

PROCESS					
Agency	**Being Curious**	**Connecting**	**Daring**	**Experimenting**	**Focus**
Ob 1, 2, 5	Ob 5	Ob 3, 5	Ob 1, 2, 5	Ob 2, 3, 5	Ob 1

CREATIVE MOMENTS			
Experimenting	**Making**	**Problem-solving**	**Predicting**
Ob 2, 3, 5	Ob 1, 5	Ob 5	Ob 2

All creative processes were observed during this episode. Beth demonstrated daring and agency in her re-design, as well as drawing upon prior knowledge of how submarines work. The children were observed making predictions before she conducted her experiment.

4.5.21 *Floating Boats* #3

Floating Boats was the fourth session of the afterschool STEM club, facilitated by Tahlia. Due to afterschool commitments, Chloe participated in this session one-on-one with Tahlia on a different day to Jett and Chloe. Figure 4.25 captures an experiment conducted simultaneously by Tahlia and Chloe.

Figure 4.25

Tahlia and Chloe simultaneously experimenting

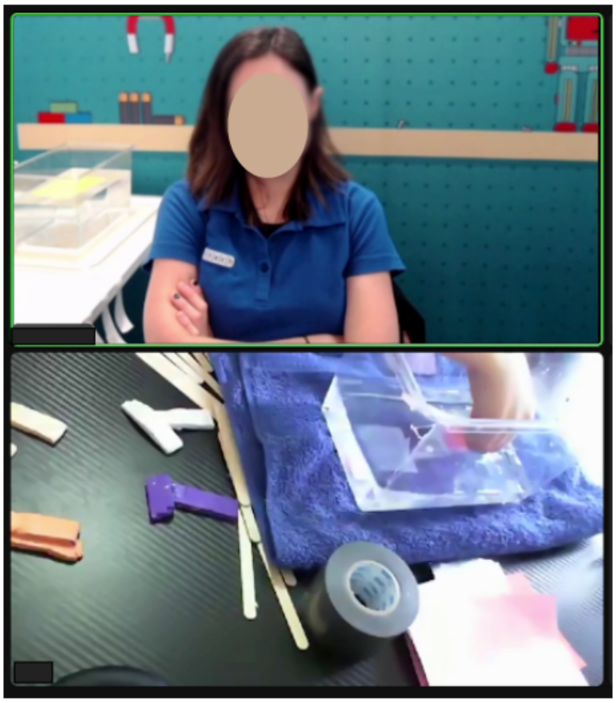


Figure 4.25 shows how Chloe and Tahlia were able to simultaneously conduct the same experiment in their own respective physical spaces. Tahlia's tub of water was behind her with her yellow paper floating in it. She was watching Chloe as she placed her pink paper in a tub of water. Chloe had tilted her webcam so that Tahlia could observe what happens to her paper in the water.

Narrative 21: ***Floating Boats* #3**

In the final session of the afterschool STEM club, Tahlia and Chloe have a one-on-one session. After Tahlia finished detailing the design brief, Chloe began to explore the materials in her pack and decided to start building with popsticks (Ob 1). Observing this, Tahlia said, *"I actually made something out of popsticks myself, see?"* and she slowly glided a popstick boat across her screen. *"Nice!"* Chloe said with a smile, and they engaged in further conversation about the materials they had (Ob 2). During this conversation, Chloe continued to use her hands to touch and hold the different materials in front of her. After a minute or so of this, Tahlia said, "*I'll let you have a think now about what you're going to build. You can test it at any time, I like to try things out and test…"* as she said this, she picked up a yellow sheet of paper and asked whether it would sink or float. Chloe confidently predicted, "*Sink, definitely. It would go all yucky…because paper and water don't go well together."* (Ob 3). As Tahlia placed her paper in the water, Chloe independently chose to follow suit by testing a pink sheet of paper (Ob 4). They observed their paper in their water tubs quietly before Chloe said, "*It isn't sinking, but it's getting wet."* Tahlia agreed, asking, "*Do you think it will stay on top of the water forever?"* to which Chloe replied, "*No"* (Ob 5). Agreeing to revisit the paper experiment later, they returned to building their boats. Table 4.45 lists the place elements that were observed during the described narrative above.

Table 4.45

Place elements observed in Floating Boats #3

PLACE					
Resources		**Communication**		**Socio-emotional climate**	
Intentional provocations	Ob 1	Intentional learning conversations	Ob 2, 3, 5	Stress and pressure free environment	Ob 1, 2
Stimulating materials	Ob 1, 4	Hearing and valuing children's ideas	Ob 3, 5	Non-prescriptive	Ob 1
Adequate materials for everyone	Ob 1	Open inquiring questioning	Ob 3, 5	Non-judgemental	Ob 1
Time for creative exploration	Ob 1	Facilitating dialogic conversations	Ob 2, 5	Allowed to make mistakes	Ob 4

TYPES OF COMMUNICATION				
Adult-adult	**Children-only**	**Dialogic**	**None on screen**	**Scitech-only**
Not observed	Not observed	Ob 2, 3, 5	Ob 1	Not observed

Table 4.45 illustrates how all elements of place were observed during this episode. Specifically, a non-prescriptive environment was observed in which Chloe was encouraged to conduct additional experiments with paper before focusing on the task

of building a boat. Chloe communicated both with Tahlia and her dad during this episode. Table 4.46 lists the process characteristics that were observed during the described narrative above.

Table 4.46

Process characteristics observed in Floating Boats #3

PROCESS					
Agency	**Being Curious**	**Connecting**	**Daring**	**Experimenting**	**Focus**
Ob 1, 4	Ob 1, 4	Ob 3, 5	Ob 3, 4	Ob 4	Ob 1
CREATIVE MOMENTS					
Experimenting	**Making**	**Problem-solving**	**Predicting**		
Ob 4	Ob 1	Not observed	Ob 3, 5		

Table 4.46 illustrates how all creative processes were observed during this episode, in particular curiosity about what would happen when experimenting with the paper and water.

4.5.22 *Floating Boats* #4

Floating Boats was the fourth session of the afterschool STEM club, facilitated by Tahlia. Figure 4.26 shows Chloe engaging in an experiment while making her boat.

Figure 4.26

Chloe engaging in an experiment while making her boat

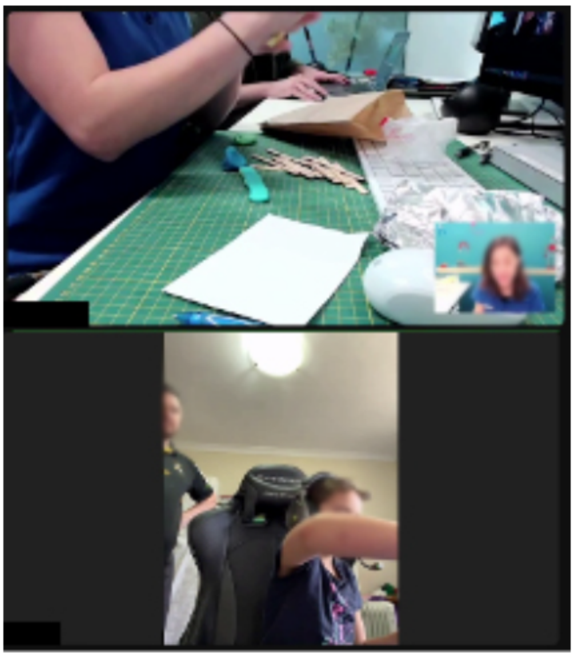


Figure 4.26 captures Chloe as she experimented with plasticine in her tub of water. She had turned her body towards her tub of water and her eyes were focused on the experiment, while Tahlia watched on. Chloe's dad stood nearby, also observing.

Narrative 22: *Floating Boats* #4

Tahlia and Chloe had spent some time getting to know the design brief, experimenting with the floating paper and discussing Tahlia's technology set-up (Ob 1). *"Alright, I'm going to put my head down and start building now,"* Tahlia said, before seeing what Chloe was working on, *"Oh wow you've already started, that looks like a great little raft so far."* Chloe was working on her task when out of the blue she says, *"I don't think plasticine would actually go good in water."* Tahlia asked her why she thinks that would be and she responded, *"because ummm plasticine is a bit solid, so it wouldn't go well in water"* (Ob 2). Tahlia responded by saying, *"I love your thinking there…what happens if a boat sinks, why does it usually sink?"* Chloe replied, *"It sinks because it's really solid and sticky…I just want to try it out"* she grabbed some plasticine and placed it in her tub of water (Ob 3). *"It sinks,"* she announced. Tahlia responded, *"It sinks? Oh. Maybe you could change the shape of it?"* Chloe took the ball of plasticine out of the water but did not change its shape, choosing instead to go back to work on her raft. Table 4.47 lists the place elements that were observed during the described narrative above.

Table 4.47

Place elements observed during Floating Boats #4

PLACE					
Resources		**Communication**		**SE climate**	
Intentional provocations	Ob 1	Intentional learning conversations	Ob 2, 3	Stress and pressure free environment	Ob 2, 3
Stimulating materials	Ob 1, 2	Hearing and valuing children's ideas	Ob 2	Non-prescriptive	Ob 2, 3
Adequate materials for everyone	Ob 1	Open inquiring questioning	Ob 2	Non-judgemental	Ob 2, 3
Time for creative exploration	Ob 1	Facilitating dialogic conversations	Ob 2, 3	Allowed to make mistakes	Ob 2, 3

TYPES OF COMMUNICATION				
Adult-adult	**Children-only**	**Dialogic**	**None on screen**	**Scitech-only**
Not observed	Not observed	Ob 2	Not observed	Not observed

Table 4.47 illustrates how all place elements were observed during this episode. Tahlia spoke directly to Chloe and engaged in dialogic conversation with her. Table 4.48 lists the process characteristics that were observed during the described narrative above.

Table 4.48

Process characteristics observed during Floating Boats #4

PROCESS					
Agency	**Being Curious**	**Connecting**	**Daring**	**Experimenting**	**Focus**
Ob 3	Ob 2, 3	Ob 2, 3	Ob 3	Ob 3	Ob 1, 3

CREATIVE MOMENTS			
Experimenting	**Making**	**Problem-solving**	**Predicting**
Ob 3	Ob 1	Ob 2	Ob 2

Table 4.48 illustrates how all creative processes were observed during this episode, as were all four creative moments. Chloe and Tahlia engaged in dialogic conversations as they experimented and explored with the materials.

4.5.23 *Floating Boats* #5

Floating Boats was the fourth session of the afterschool STEM club, facilitated by Tahlia. Figure 4.27 captures Chloe's dad as he encouraged her to test her construction.

Figure 4.27

Chloe's dad encouraging her to test her boat construction

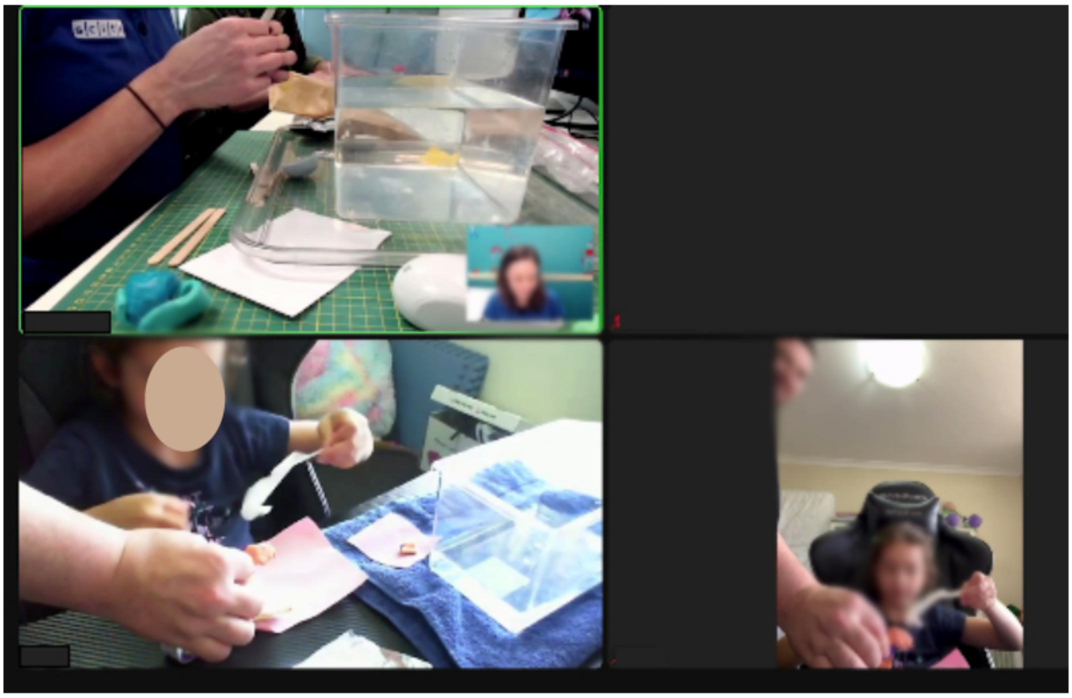


Figure 4.27 shows the support Chloe received from both her dad and Tahlia during this design challenge. Her dad was physically assisting her by holding parts in place while she glued them together. By this point in the session, her dad had set-up two simultaneous web cam-enabled devices so that Tahlia could watch Chloe's face as well as her construction.

Narrative 23: *Floating Boats* #5

Chloe was busy working on her boat design, having constructed a flat base out of popsticks she was using masking tape to attach a flag made of plasticine to the curved front (Ob 1). *"I don't know how I'm going to stand it up,"* she said after a couple failed attempts. *"That's okay,"* Tahlia said, *"do you want to try it without the flag first and see if it floats? You can always keep building afterwards."* But Chloe responded quietly, *"I don't want to try it,"* and both Tahlia and Chloe's dad laughed empathetically (Ob 2). Her dad then encouraged her to test the boat, *"That's how you learn. You learn from making a mistake"* he said gently tickling her head. *"I want to test it when I'm done,"* she said. *"That's okay, you can keep building,"* Tahlia jumped in. Her dad tried to encourage her again, *"If you do test it now, you might see where it leaks and then you can fix the leaks."* Chloe ignored him, continuing to work with the flag and masking tape. *"Dad, can you hold this flag?"* she asked, and the three of them had a little chat and joke while they kept building. Her dad offered some feedback as she continued to struggle with the flag. At this point, Tahlia asked Chloe if she thought her boat would float (Ob 3). Chloe and her dad watched as Tahlia tested her raft, which floated successfully until she added some bolts. Chloe appeared engaged, laughing, and enjoying observing the experiment. She helped predict what would happen to Tahlia's boat and provided suggestions for helping it to float better (Ob 4). *"That's what yours needs to do, Chloe, hold these* [bolts]," her dad says, nodding towards Tahlia's construction on the screen. *"Let's put it in and test it, see if it works."* This time, Chloe agreed and gently picked up her raft and popped it in the water (Ob 5). Table 4.49 lists the place elements that were observed during the described narrative above.

Table 4.49

Place elements observed during Floating Boats #5

PLACE					
Resources		**Communication**		**SE climate**	
Intentional provocations	Ob 1	Intentional learning conversations	Ob 4	Stress and pressure free environment	Ob 1
Stimulating materials	Ob 1	Hearing and valuing children's ideas	2	Non-prescriptive	Ob 2
Adequate materials for everyone	Ob 1	Open inquiring questioning	Ob 3	Non-judgemental	Ob 2, 3
Time for creative exploration	Ob 1	Facilitating dialogic conversations	Ob 2	Allowed to make mistakes	Ob 2, 3

TYPES OF COMMUNICATION				
Adult-adult	**Children-only**	**Dialogic**	**None on screen**	**Scitech-only**
Not observed	Not observed	Ob 2	Ob 1	Not observed

Table 4.49 illustrates how all place elements were observed during this episode, specifically the support and non-judgemental environment Tahlia fostered by not pressuring Chloe to test her boat before she was ready. Chloe was seen engaging in conversation with Tahlia and her dad during this episode. Table 4.50 lists the process characteristics that were observed during the described narrative above.

Table 4.50

Process characteristics observed during Floating Boats #5

PROCESS					
Agency	**Being Curious**	**Connecting**	**Daring**	**Experimenting**	**Focus**
Ob 1, 5	Ob 4	Ob 1	Ob 5	Ob 5	Ob 1

CREATIVE MOMENTS			
Experimenting	**Making**	**Problem-solving**	**Predicting**
Ob 5	Ob 1	Ob 4	Ob 3, 4

Table 4.50 illustrates how all creative processes were observed during this episode, as were all four creative moments. In particular, Chloe demonstrated agency over her boat design and when she chose to experiment with it.

4.6 THEMATIC ANALYSIS OF INTERVIEW DATA

The semi-structured interview data has been presented below from the three case study children: Beth, Chloe, and Jett along with their respective parents, the two Scitech facilitators, Milly and Tahlia, and the classroom teacher, Miss Bird. As outlined in Chapter 3, themes were developed through exploring and developing an understanding of the patterns within the data through the lens of the study's research questions and *A-E of Children's Creativity* framework. The themes generated through this process are organised under three categories, chosen by the researcher: *experiences, affordances,* and *challenges.* These categories assist in the logical categorisation of the themes that emerged.

4.6.1 Experiences

The following themes emerged relating to experiences of the children while engaging in the online Scitech sessions, both at school and home.

4.6.1.1 Intersection of online delivery and physical resources

This theme addressed the impact on the children by engaging both with the demonstrations and conversations on-screen with Tahlia or Milly, as well as actively participating in hands-on tasks using physical materials provided to them by Scitech.

Miss Bird spoke about the impact of having the hands-on *Mini Volcano* session following on from the *Science is Spectacular!* show:

> I think it added lots of value. Having their own opportunity to go and take what they learnt from that first science show, and actually do an experiment was great. They loved it. They were very, very engaged. You could see like, the awe on their faces when their experiment happened.

She also described the experience of having Milly being online and how it provided opportunities for the children to gather new knowledge to share with her:

> I feel like Milly was always here, and for the most part it always worked very well. There weren't many constraints [being online], I didn't feel that it was so different than if she was actually here in the room…I didn't feel like the screen stopped the children from developing that relationship with Milly…They would be so excited. They were telling me they wanted to tell Milly all these things, [they were] grabbing things from around the room [to show Milly] when they had her on the screen, and that kind of tied in with the lessons she was teaching them. I felt that was important, because it wasn't a constraint at all having her not be here in person.

Miss Bird further reflected on the STEM workshops and how the hands-on component was beneficial for Jett, saying:

> [For Jett] it was probably more of an experience that he could actually make and create...for him to be able to have those opportunities to actually make slime and make the maker shaker…I think those were really good opportunities for him.

When interviewed, Jett spoke positively about having the opportunity to be hands-on during the workshops.

Reflecting on the *Floating Boats* afterschool STEM club session, Tahlia felt it was an effective activity for the children to engage with:

> Because of the simplicity of something sinking or floating…it's so simple that it allows for more creativity because we know already what sinking and floating is…you can keep testing it out over and over, and you can keep changing it.

Chloe spoke about how the new thing she learnt during the afterschool STEM club sessions was "[that] through testing cardboard and silk could float in water." Speaking specifically about the one-on-one session with Chloe, Tahlia described:

> [At some points] we just changed direction altogether…that was really fun to be able to that one-on-one and say, 'okay we don't have to stick to building a boat. Let's try and make things sink' which is essentially learning the same principles, it's discovering how different materials can behave. It was a great science experiment…she was thinking about all the different ways to do something, which I think is total creativity.

Reflecting on the nature of the online sessions and how hands-on activities offer opportunity for creativity, Milly said:

> I think given what we do, there's a lot of opportunity to foster creativity in the online environment. And there's certain activities which 100% would do a great job of that. Something like setting a task with a certain amount of materials and seeing how children solve that problem and be able to share that online would be a really great way of fostering creativity. I feel the sky's the limit when it comes to fostering creativity through online engagement and the online medium.

4.6.1.2 Focus strategies for the online environment

This theme addresses the way Tahlia and Milly employed a range of focus strategies during their online delivery of the shows, school-based STEM workshops, and afterschool STEM club sessions. Participants reflected on the way these focus strategies supported the children's learning and creativity. Specifically, the strategies of questioning, re-directing focus, and providing quiet time to work on tasks.

Of the way Milly fostered the children's creative thinking during the school-based STEM workshops, Miss Bird spoke specifically about her use of the questioning focus strategy:

> I think Milly asked a lot of open-ended questions, which really got the children thinking. It wasn't just a 'yes' or 'no,' it was, 'well, I thought this…' I also thought Milly was very good at taking answers. Even if they weren't always exactly aligned with the question, she would kind of bring it back in. She would find a way to connect it, which was great.

Speaking of Jett's creative process during the afterschool STEM club, Tahlia said:

> Jett definitely had a lot of fun. He wasn't always working exactly toward the challenge itself. When he was, it was great to see his different ways of thinking. He did often use things in very different ways.

She continued by reflecting on his progress over the four sessions, sharing how her focus strategies assisted in helping Jett feel comfortable within the online learning environment:

> [His progress] definitely did evolve. I don't think he really made a house in the first session. Or he did, but it was very basic…it was quite tricky to get him to start building. And I think that comes back maybe to having less confidence in terms of his ability to do things. So he maybe decided instead to do his own thing, and have some fun…[when he grabbed the bow and arrow] I was like, 'oh no'…and there were times I recommended that maybe he could use something and [he] looked at it and went like, 'I don't think so' and did his own thing…In the beginning [he] wasn't showing as many markers of creativity. But then toward the end with the boat, I think he showed a huge amount of creativity. I think that did develop as maybe he realised that 'it's okay.' I'm not going to be like, 'Oh Jett, you've done the wrong thing' I'm going to be like, 'Oh Jett, I want to see you trying this out.'"

Jett's mum also reflected on the focus of the children, and Tahlia's strategies for keeping them on task:

> [They went off-task] possibly because there was no real authority in the room. So, they just went off on a tangent. Tahlia was very patient and always tried to draw them back in. Her listening skills were really good… [at times] they were all off doing their own thing…I think they were all just excited to get online.

Tahlia spoke about the intentional effort she made to provide quiet time for the children to focus:

> In the first two sessions, I think I was talking too much, and the children didn't quite get the build. I think it was by the third session when we really decided to give them a bit more [quiet] time. And that was beneficial. The children chatted between themselves and still asked questions when they needed to, and I could feel the children were a bit more relaxed. Because not everyone immediately comes up with an idea, they might have to play around with things first, and work out what they're going to do…it can be hard to gauge the level of creativity or engagement online. Engagement and creativity can be, 'let's do this' and 'let's do that' and be really loud. But it can also be a lot of thinking and internal creativity.

Reflecting on Tahlia's approach, Chloe's dad said:

> Tahlia was really engaging. You could tell she could read the children, knowing at times when she had to step in and quieten them down. And then other times, you could see she let them go. That was impressive, doing this over a video call.

Chloe spoke positively about having quiet time during sessions to focus, saying, “The thing I didn’t enjoy was when things got too hard for me to do, and Beth and Jett kept talking and I couldn’t focus.” Beth’s mum also observed this, noting that at points her daughter would, “Try and talk to the others and get them distracted. I think at one point she was starting to try booking in a playdate with Chloe.” She went on to comment that, “I think in person they could have gotten more distracted, I reckon they could concentrate more on the activities online.”

Reflecting on working with Beth during the online learning experiences, Tahlia explained the strategies that were most effective:

> Beth, I believe was quite afraid of failing. So having the other children there [so she could] see what they were doing and have them give her a little bit of support to be like, ‘you can do this, look at mine my egg broke but it’s okay’ and she’s seen that I’m not going to be like, ‘oh no, the egg broke you’ve failed,’ you know, to have her witness the other students also having the same struggles I think that eventually worked in her favour to have more students around as well. I think she would really benefit from teamwork in terms of having other team members to rely upon to say, ‘oh no, that’s perfect.’ She was very focused on getting it exactly right. Which meant that often she found it difficult to stop working…so I think a one-on-one session with Beth would have been quite tricky. I think certain children really benefit from group work and others find that a little bit harder when they’re feeling maybe on the spot.

4.6.1.3 Intentionality of activities

This emergent theme centres around how the intentionality of activities during the school workshops assisted the children in developing their creativity, by providing structure and opportunities to think deeply.

Of the *Bend, Twist, Stretch & Squash* investigation, Miss Bird reflected:

> I really liked that it was very hands-on, they got to go and explore…I feel like it worked in well with Investigation Time because a lot of it was very

> similar…in that they had to experiment and investigate, and then take notes and write it down. I liked that it got them moving, thinking, and really investigating…The children were doing things that you wouldn't expect with some of the items. You wouldn't think that the tennis ball would twist, but they'd have a go anyway.

Reflecting specifically on Chloe's experience during the activity, Miss Bird went on:

> She was a bit more patient with these activities, because I feel like sometimes, she's kind of like, 'I just want to do it now.' Whereas with Milly she was very engaged in whatever they were learning about.

4.6.1.4 Familiar resources

This theme addresses how Scitech provided materials for the children to create and experiment with that were familiar to them. It was noted by participants that this familiarity allowed the children to engage in positive levels of creative thinking. In reflecting on the children's maker shaker designs, Milly said, *"*Beth and Chloe were quite intentional about their designs and how they decorated their shakers." Beth elaborated on her design concept:

> I made a bunny [out of my shaker]. The pipe cleaner gave me an idea, so I folded it around its bottom and I kind of twisted and scrunched it and pulled to make a little bunny tail...I thought of this because I really like bunnies and bunnies are soft.

When asked if she would do anything differently next time, she said, "I might instead have drawn Olaf, Elsa, Anna, and Kristoff on it…because I enjoy Frozen." She went onto describe how she was heading to Perth soon to watch Frozen the stage production.

In reflecting on Beth's creativity during the school workshops, Milly said:

> I found Beth to be [pause] quite creative in her construction activities. And quite confident in her ability to make something. But in terms of pushing boundaries, I think she was happy to do that on an artistic level, but maybe not so much with her other thinking and ideas. It seems like she was happier to freeform it on low consequent sort of things. Whereas when it came to like, 'I'm actually taking creative risk' she was a little more hesitant to take that step.

In reflecting on the telephone challenge, Milly said:

> It was interesting when they were trying to work out their telephone and trying to figure out how to make it work. Jett and Beth worked it out almost straightaway. So, they'd obviously gone, 'okay, here's a problem we have a big lot of string in between, it's not quite working now, what can we change?' and so that next step of 'we will stretch it out' for me demonstrates creative thinking because they were thinking about the options they have and giving it a go to see what happens. So that was one of the big ones that I was super impressed with, and their integration of knowledge.

Jett explained how it felt to complete the challenge:

> When we connected it up it sounded like, so awesome. It's because I figured out you need it straight, but when it's like flat, going like that [demonstrates with hands] it's hard to hear.

Tahlia reflected on the impact the materials on the children's creativity:

> If you're focusing too much on how to cut the masking tape, or how to fold things [you're distracted from the build] …when something becomes second nature, you're able to more creative with how you use that thing. In my experience it's been a bit tricky in terms of children's fine motor skills…we really wanted to make it hands-on in terms of folding and cutting, yes, that may be a challenge. But towards the end, they were able to use all the items and then after practice, got to think outside the box a bit more.

Reflecting further, Tahlia said:

> I think they all progressed in terms of their abilities to get started, make changes, test, and take risks. And also, to be okay with potentially not being successful…because they were all very engineering-based challenges in terms of putting bits of paper and sticking things together. They had experience with those skills [as the sessions went on]. So, then they were able to get started quicker and be a little more creative with their designs and processes.

Speaking of Jett's creative process during the *Floating Boats* session and use of materials, Tahlia said:

> Jett really only used one item, we had lots and lots of materials that he could choose from…[but] he stuck with just some al foil. But he tried that al foil in almost every single way and shape that he could… He also went straight to

> just putting all the nuts and bolts into the boat. And I think he probably knew what was going to happen [laughs] but he tried it anyway… Rather than worrying about building the best, most amazing boat ever, he just tried the same boat in lots and lots of different ways…he discovered, 'oh, I'm going to turn mine into a canoe' which I thought was great because that's something he knows that floats. And I think it was the first time he was really successful in the challenge as well; he had that real light bulb moment where he could actually put in two bolts. Then he realised that three bolts were too heavy…he was the first and only person to try putting popsticks inside the boat, to see how much weight it could hold. That's not something I even mentioned, he obviously thought, 'well the popsticks are light. So, I'm going to make the increments of weight smaller' to see just how little to increase. It's very science, very creative thinking…it was fantastic, I loved it.

Jett reflected on his creative process during the *Floating Boats* session, saying that he used the al foil, "because it was easy to use. And it could float perfectly because it was very light." He said he drew upon existing knowledge of al foil being light before working with it. His mum shared:

> As soon as [the activity] started, he just wanted to test everything. I think he must have tested it up to twenty times…until he gets it right, [he's] a little baby perfectionist, he's creative…and he doesn't care if it bombs out. He'll just be like, 'oh well, I'll just try again'… he has no fear. After the sessions finished, he would still try to perfect it all the way through.

Milly said she was interested to see how the children went with the maker shaker task, using familiar items in new ways:

> Seeing how they planned to attach their paper to their tubes, because the materials we gave them [could be] quite tricky for a child who maybe has never seen things attached with elastic bands. You don't know if it's going to work, or if that's going to be a decent solution. So, it was cool to see them kind of problem-solve their way out of very narrow boxes of materials to create their own shaker.

4.6.1.5 Perceptions of online delivery

This theme explores the perceptions the children had about the Scitech sessions being delivered online. Overall, the children expressed minimal concerns with engaging with online delivery, overall, it was a positive experience for them. There were also times their comments appeared contradictory. For instance, in the same interview about the afterschool STEM club, Beth said of the online delivery, "It felt weird. we could still hear the others even though they're not at our home…It was more fun [being online because] it's kind of like phone calling them." However, later she said, "I watch TV all the time. So, it's normal."

Jett said that although he enjoyed the delivery being online, it would have been fun "if we could have helped with stuff" such as being a volunteer during the experiments. Miss Bird also mentioned this, however noted that in the face-to-face show only one child was able to volunteer anyway, "So it wasn't that much of a difference for the rest of the class."

Reflecting on the children's experiences of the online delivery, Miss Bird said:

> There weren't very many differences [being online]…There weren't many constraints, and I didn't feel that it was so different than if she was actually here in the room…I didn't feel like the screen stopped the children from developing that relationship with Milly…It wasn't a constraint at all having her not be here in person…They didn't think it was weird or kind of question that she was on a screen.

She also commented on the positive experience of having multiple sessions:

> Having Milly every week, sometimes two or three times a week [meant] they really built that relationship, and they wanted to share all the things that they knew.

When asked about the delivery being on the AV screen, Chloe did not express any desire for the show to be in-person, simply noting that the key difference was, "That Milly was on a TV and not here in real life, so we couldn't touch her." Of Chloe's experience learning online, her dad reflected:

> During the first session, it was all exciting that the computer was on, and I can see myself on the screen and my friends. But during the later sessions Chloe knew it was a bit of business as well. 'I've got a job here' and she was just real keen to open [the packs] up and get into it.

4.6.1.6 Small group delivery

This theme centres around the impact of group size during the afterschool STEM club had on the children's creativity, engagement, and participation. Some of the adults interviewed spoke positively about the small group size during the afterschool delivery. For instance, Beth's mum said, "I think that it was a nice small group. If it was any bigger, I think the children would just try and talk over each other and might not be heard."

Tahlia supported this notion:

> [If delivering face-to-face], it's more likely to be in a large group setting, so they might be partnered with someone else. Then the collaboration happens with the other child. So, by having these sessions at home, and having only three participants meant it felt a lot more personal.

Tahlia reflected specifically on the impact of group size regarding Chloe's work ethic, saying that:

> [Chloe] wouldn't verbalise a huge amount...I would have to be like, 'hey Chloe, what are you doing over there?' and she would show me, and it would be great! I would be like, 'wow,' I've been chatting to the other children and suddenly Chloe's built one of the best ball runs I've ever seen in like, five minutes.

She said that the smaller, online environment "seemed to really work for her" and wondered whether being in a larger, louder classroom environment would cause her to get distracted. This coincidentally corresponds to an observation of Miss Bird who noted that, "[Chloe's] brother was in the other class. So, I noticed that when he sat next to her, she got very distracted and would turn around and have a chat with him."

4.6.1.7 Positive experiences

This theme was concerned with how the children enjoyed each of the STEM session presented to them by Scitech. When interviewed, each of the three children responded 'yes' when asked if they enjoyed the *Science is Spectacular!* show, *Quiet as a Mouse* puppet show, the four school-based STEM workshops, and the afterschool STEM club sessions. For instance, when asked what they enjoyed most about the *Science is Spectacular!* show, Beth shared, "It was so cool when [Milly] couldn't do the balloon, but then she like [gestures] had already made that dog and just put it under her desk." Chloe responded that her favourite part was, "When [Milly] had bubbles on her hand, and she lit it on fire, and she was holding fire on her hand!...And I'm starting to love science." Meanwhile, Jett said that he enjoyed, "When [Milly] put the hot water and the cold water together and made a big explosion...I love explosions."

When asked about the school-based STEM workshops, each child had a different response to which was their favourite. Beth could not choose, stating that "all of them" were her favourite. Chloe said that the *What's in the Cup?* investigation was her favourite workshop activity, "Because I thought I knew what was in one of the [cups]…It sounded like sand, so I guessed sand." Jett's favourite activity was the *Bend, Twist, Stretch & Squash* investigation, "Because I got to do all the squishing."

In relation to the *Quiet as a Mouse* puppet show, Beth shared that her favourite part was, "That the cat's eyeball went through the keyhole [laughing]…and the big tail and paws... [Melody the cat] was funny." Similarly, Chloe also referred to Melody the cat as her favourite part, "Because it wagged its tail above the cheese, and its eye was crazy." For Jett, his favourite part was the interactivity saying, "I enjoyed when [Milly] let us shake our shakers."

Of the afterschool STEM club sessions, each of the three children shared that they chose to continue working on the design challenges after the online sessions ended. Of their favourites, Beth shared that she, "Liked it a lot. I liked it because it was challenging," although she could not choose a favourite session, saying that she enjoyed all four equally. Chloe's favourite design challenge was *Floating Boats*, sharing, "My favourite part was then Tahlia put her boat in the water and it didn't sink and then she put three or four bolts on it. And then it just sunk down…it was funny!" Jett's favourite activity was also the *Floating Boats*, sharing that, "You had to build a boat and float it. Sometimes it would keep on sinking but I liked it floating!"

4.6.1.8 Summary of Experiences

The key themes to emerge under the heading of *Experiences* related to how the children perceived, enjoyed, and interacted during the school and home-based online sessions. Specifically, children engaged in active, hands-on learning opportunities which highlighted an intersection between the online delivery and the physical resources with which they were provided. This was further supported using physical resources that were familiar to the children. Tahlia and Milly employed a range of strategies to help guide the children's focus during the online activities. The small group size for the afterschool STEM club was raised as a positive approach to supporting children through an online platform. The children spoke of their enjoyment at participating in the Scitech sessions, and while they noted it felt different to be learning online, they did not consider it a negative experience.

4.6.2 Affordances

The following themes relate to affordances of the online delivery that emerged in relation to the school and home-based sessions.

4.6.2.1 Enhanced viewing experience

This theme addresses how the nature of online delivery for the *Science is Spectacular!* show and *Quiet as a Mouse* puppet show offered unexpected viewing benefits for the children. The 'wow' factor of a Scitech science show appeared to translate in an online delivery, with Miss Bird reflecting:

> I think they were very impressed. I thought that they [the *Science is Spectacular!* show and the *Quiet as a Mouse* puppet show] were probably the most engaging for the children. They got to kind of be involved. And I guess it was just exciting and different. They got to learn lots of cool things, especially with the chemistry…having those really exciting chemical mixing reactions, things that they don't normally see in our school environment…I thought it was actually really good that they could be up close [because of the zoom feature of the live-stream camera] and really see things, because when we were sitting in the hall [when Scitech visited the school in March], we were sitting quite far away…it was quite hard for them to see what was happening because they could only see from the front perspective. Although they were all sitting in different spots [in the classroom] they could still see the same screen. So having that view was definitely very helpful.

Reflecting on the *Science is Spectacular!* show, Chloe said she loved it when, "Milly was holding fire…now I want to try holding fire [laughs]," she also spoke about the elephant toothpaste eruption, making the connection that it looked like "snot." Beth spoke about Melody the cat being the favourite part of the *Quiet as a Mouse* puppet show, "I got a bit frightened when the eye came out…I was like, 'whoa!' It made me jump." She also spoke of how she felt when Racket was sad, "I was a bit sad for Racket when he was crying."

Miss Bird observed high levels of engagement in Beth during the shows:

> I think her behaviour was very similar [to normal classroom activities]. She's a great listener on the mat, so the whole set up with the TV was fine for her. Engagement-wise, sometimes Beth is funny. She listens, but she won't look. But I did find that she for the most part was looking [at Scitech on the TV screen] so she was engaged with all her senses.

In reflecting on the online delivery of the normally in-person show, Milly said:

> I really liked the ability that technology gave us to do some different things… I really enjoyed doing the slow reveal of the puppet stage because that's not something we normally get to do. Normally it's just like, 'oh, you're in this space already! You've already seen all of the set and we just have to pretend you haven't until we start engaging with the space.' But being able to seamlessly do the 'button shrinking gag' was really fun.

Milly reflected on the potential for utilising the technology affordances of online delivery further:

> I really like the ability that technology gave us to do different things. Something that we explored, but never quite used, was green screen…That sort of technology would be really fun for a theatre show or puppet show…we could quite conceivably make a fresh online show that really uses the technology to our advantage. We could do different cuts to different characters and different spaces. That would be amazing and something that we absolutely could never do in a puppet theatre.

A key consideration when undertaking this online delivery for Scitech was how their shows would translate to an online mode, as Milly said:

> When preparing, one of the biggest considerations that I had for both the shows was just, 'is this going to be visually interesting?' There's a lot of cool demonstrations that rely on other senses. So even something like exploding a hydrogen balloon, that doesn't translate as well over the screen because you can still see the flame and hear that noise. But the noise isn't coming straight from the explosion, it's coming through your screen. And you don't feel any of the shock wave or the heat…and with the puppet show one of the biggest things we need to consider are eyelines. So, if we're up on a stage, we make

> sure that the eyeline of the puppet is correct. But then how do you do that for children who are on a screen in front of you, but you can't necessarily be looking at a particular child.

Milly further commented on the potential of online delivery:

> I think with theatre shows and demonstrations, you would be able to do things on a much smaller scale, that still would be interesting. Whereas when you're in a space with like, 140 people in it, a thing this big [gestures small with fingers], no one can appreciate that. So that's another kind of opportunity we get from online delivery.

4.6.2.2 Supporting daring and resilience

An unexpected affordance observed during the afterschool STEM club sessions was the way the online environment provided a safe space that encouraged the children to be daring and resilient while engaging in their design challenges.

Reflecting on resilience and daring during the home sessions, Tahlia said:

> I think building that resilience in children and showing that it very rarely works the first time, every time [is important]. And if it does, it's probably a fluke [laughs]. This skill is important to be building in children because they're afraid of getting things wrong. There's a lot of pressure on them from expectations that can be quite overwhelming…and maybe I'm using the wrong term, it's not 'failure.' It's just 'trying it out.' It's 'experimenting.' You're just discovering something new. You're discovering that, 'oh, that's not the best solution.' So, it's just the idea of reframing that and I think I did sort of change my approach week-to-week a little bit, which just happens naturally as you start to learn. That would happen naturally at an in-person session, you go, 'okay well that didn't work this time. This child is struggling with feeling like they're doing the wrong thing. So, I'm going to show you here's stuff that doesn't work.'

Speaking of Beth's creative process specifically, Tahlia said:

> She's capable of building with her hands and making things, and I think an aspect of that is also she put a lot of pressure on herself and was visibly the most anxious when it came to the testing side of things...She's obviously very, very talented when it comes to building and making. But when it comes to the ability to be okay with failure and resilience around failing, that is something I noticed her struggling with.

When asked about responding to children's 'fear of failure' during online delivery, Tahlia said:

> It was a challenge, absolutely. Because in person, you can be like, 'that's okay, I'm going to show you mine failing.' Online, unless you're lucky enough to be with another person in the room to help feel more comfortable…I think if they are in a [face-to-face] group scenario where they see someone else's that didn't work out that means they're not alone, and they're not the only person who might be failing. I think it was definitely a challenge during the online delivery knowing that there are people watching you.

Discussing Tahlia's strategies around resilience and 'failure,' Beth's mum said she felt they were helpful for Beth:

> I think it did help, such as when they were doing the ball run. I noticed Tahlia did a ball run and tested it, and it didn't quite go as it was meant to, and it was okay. I think that helped Beth.

She also spoke about how engaging in live sessions with Tahlia appeared to be more helpful for Beth that simply following YouTube tutorials:

> Sometimes she watches [YouTube craft tutorials] but she doesn't always stay motivated enough to follow along. Whereas when it was live and someone was talking to her, she got very into it.

Of the four afterschool STEM challenges, Beth said she found the floating boat the most challenging, but that she learnt "about giving it a go."

Beth's mum observed how, over the course of the four afterschool STEM club sessions, Beth demonstrated greater confidence and persistence during the builds:

> She just got better…she learnt that it didn't have to be a pretty thing. It just had to work…it was about testing. And if it didn't work, it just made you learn something else…I was scared she was going to be really disappointed [when the boat kept sinking]. But for her to turn it into a positive instead, was nice. Because in the first week when she was doing the *Wind Houses* activity, she was very protective of it, and didn't want to use a hair dryer in case it blowed over. Even with the eggs she really didn't want to drop it in case she actually broke the eggs. So, I was surprised with the boat that when it did fail, how she turned it into a different positive.

Beth’s mum went on to discuss Beth’s development during, and after, the Scitech sessions:

> I was surprised that she was so independent. Usually when things get hard, she would call me for help. But she’s doing it less and less now and very little during the Scitech sessions.

Reflecting on Beth’s creative process during the floating boats activity, Tahlia observed, “She built the biggest boat, she utilised all the different materials for the boat.” When asked about the moment Beth turned the boat into a submarine she said:

> It’s really interesting, because it could be masking ‘I don’t want to see that as a failure because I don’t like the idea of failing.’ Or it could be she’s taken something that was a failure, and made it into a positive, which is a really great thing…and it’s creative thinking…I love that. There’s a little bit of humour in, you know, turning something that might be a bit uncomfortable into something a little bit humorous.

Reflecting on the afterschool sessions, Jett said some parts of the activities were easy and some were challenging:

> So, for the building a boat it was easy, but the house building was hard…because it was hard to put on the roof... [because it was] something that I haven’t done before.

He shared how he continued working on all his activities after the online sessions ended. Of the *Wind Houses* activity he said, “I made it into a triangle like this [gestures]…I blowed it again. It stayed up.” His mum added:

> After the workshops were finished…he would still keep building and stuff. So, he would still work on it for like an hour afterwards…I think there has been an increase in his confidence and skills, in looking at things a little bit differently. And now he’s always thinking, ‘oh, I can just get the Blu Tack’ [laughs]…Like when he builds something for his cars, he would just make them a little bigger. And he uses more things now, whereas before he would just get two boxes and make triangles [gestures]. But now he’s using four boxes. He’s always building. [He’s going back to previous builds] and making them bigger. So, his one-dimensional builds are turning into three- and four-dimensional.”

Jett agreed, saying he had learnt, “How to build with more and more detail.”

Reflecting on the *Egg Drop* challenge, Tahlia said:

> I think it was probably the trickiest for them. Because it was something they didn’t want to break…It’s something that we do with older children. So, it was probably a bit of a challenge for them, which I wanted as well!

The three children spoke positively about the *Egg Drop* challenge. Jett’s mum spoke about how he persisted with the challenge after the session ended, “…and that egg drop. He just wanted to drop eggs, but he needed them for his pancakes his dad was going to make for breakfast, hey Jett?” [Jett nods].

On Chloe’s commitment to the tasks, her dad said, “You can tell like, just the focus…like, ‘I want to get this right. I want to make this work.’ So, she definitely enjoyed it.” Chloe agreed and shared that she continued working on all the activities after the sessions ended.

4.6.2.3 Increased parental involvement

This theme addresses the way the afterschool STEM club sessions provided opportunities for parents to become involved in their children’s learning and creative processes.

Tahlia explained, “It was great to be able to experience children being at home and being able to interact with their families.” Beth’s mum also shared:

> I kind of forgot [about the Scitech sessions] when she was doing them at school…She never tells me much. When the home ones happened, she loved it. Every time she was excited to leave school and come home…I would try to put my head in there every now and then, but I was busy unpacking lunches and getting ready. But it was cute seeing her interact and doing it herself and being independent. Because yeah, at school she never tells me what she does.

Beth shared that she enjoyed having her mum there to help her. Tahlia observed the way Beth’s mum appeared to get more involved as the sessions went on:

> I think in the beginning, Beth's mum was quite busy and wandering about the house, but [by the third session] they built a really great ball run together and had a lot of fun with it.

She went on to compare the experience of parents at Scitech's face-to-face workshops:

> It depends on the style of workshop, but a lot of the time…the parents may stand around outside the room and have a chat to the other parents. They're not necessarily always getting involved in the process…so having them as an active participant was really great. [Having the children] be able to utilise their own space and having the adult participation to help facilitate that learning at home is so valuable. And that's what we really strive for, is to not just have science in the classroom or Scitech, it's science everywhere.

Of Chloe's dad's involvement, Tahlia noted:

> Chloe's dad was sort of hanging out in the space [study] the first session. And then in the second session, he started helping out a little bit more. And then by the last session, he was a real active participant in building a boat with his daughter. That was one of my highlights.

Of all the parents, Tahlia said:

> I remember in the first session, the look on the parents' faces watching their children, doing things they maybe didn't realise they were capable of doing. And sort of seeing them in a different light…That collaboration with their parents is a very, very special thing…[Parents] might not have been 'science people' themselves…It can be very daunting for families to feel like they're educators. So having them there was beneficial…Hopefully this will mean they can be armed with a couple of activities to do with their children next school holidays!

4.6.2.4 Utilising the home environment

This theme explores the benefit of the children participating in the afterschool STEM club sessions from their own homes. Specifically, an affordance noted during the afterschool STEM club sessions was the ability for the children to incorporate their physical environment into the activities they were doing during the online delivery. As Tahlia explained:

> The ball run was really great…because the children could then use things from around the house. It was very cool that they could utilise the table height and things like that…Chloe and Beth ended up building really long bridge-like constructions, it worked out well in their spaces.

Being at home also meant the children did not have to finish the activities when the session finished. As Tahlia explained:

> The benefit is that they have the materials, they can look around their homes and see the thing they've built and continue building it…They can put the boat in the bath and try it out. They can try and blow their house over with a hairdryer. Being at home and having the ability to be already in that space, you can just go back and keep working on it. It was great.

Chloe's dad described the benefit of being in the home environment:

> We're both working full-time, and so with the drop off [of the Scitech kits] it was so much easier. It was really a case of just setting them up, and away you went. No being somewhere at a certain time, and then trying to manage all that. The ease of it was great. [Another benefit] was that you're not limited by who is running the session, if there's a talented person somewhere else, it's great. You could just really involve anyone. And going forward, because it doesn't matter where you are you can dial in, have a go. Even If you got a shopping list to go and buy the materials yourself you could do it.

4.6.2.5 Agency and independence

This theme presents an unexpected affordance of the online delivery at school, which was the way it provided an increased opportunity for the children to investigate on their own. As Miss Bird explained:

> I think it was great they could be here with Milly on the screen and have her deliver the knowledge, and then take time to go and investigate by themselves, then come back and share that knowledge. Which is different than if she was here, because she would be helping them the whole time. Whereas they actually had that time to go and be curious and create on their own with the teachers, but then come back and go, 'oh my goodness, I've actually learnt all these things, Milly, and I'm so excited to share them with you.'

4.6.2.6 Foster relationships with regional schools

This theme addresses the opportunity that online delivery has in fostering ongoing relationships with regional schools. It was observed by Scitech and Miss Bird that the online delivery afforded an additional opportunity to connect with schools they otherwise would not see for many years. As Milly explained:

> Normally, Scitech has the goal that we see every regional school once every three years, but three years is a long time. So if we could digitally get into their school and just make contact and have that experience with them, I feel like it would help us to reach them in a different way to how we have in the past few years where it's been like 'we get Scitech!' and then we go, and then it's 'we get Scitech!' and then we go…it would promote ongoing relationships with schools [and] give us the opportunity to be there more often without having to send a crew out and tripling our staff.

4.6.2.7 Summary of Affordances

The key themes to emerge under the heading of *Affordances* related to unexpected benefits experienced by the children while participating in the school and home-based Scitech online sessions. Specifically, it was observed that the online delivery afforded an enhanced viewing experience during the school-based shows by allowing all children, regardless of where they were sitting, to view the show. Additionally, the online environment afforded a positive socio-emotional environment in which children were able to foster their daring and resilience during creative tasks. The afterschool STEM club sessions also provided parents with the opportunity to be actively engaged in their children's learning, and the children were able to make use of their home learning environment to extend their creative designs. The children were also afforded additional time and space to exert agency and explore independently, as the distance imposed by the screen meant the Scitech facilitator was not able to observe and intervene during the children's investigative time. Finally, the online delivery gave Scitech the opportunity to foster their relationship with a regional school by providing more frequent delivery of engaging STEM services.

4.6.3 Challenges

The following themes relate to challenges of the online delivery that were raised by adult participants during their interviews.

4.6.3.1 Materials

This theme addresses the challenge for Scitech in preparing and sending materials to the school prior to their sessions. Milly reflected on some limitations to online delivery:

> I think [there were] slightly less creative opportunities mostly because of the resourcing – needing to send a box and not having infinite craft supplies [laughs] did sort of limit that a little bit…For example, *What's in the Cup?* or *DIY Shakers*, just trying to pick things that would be user friendly.

4.6.3.2 Time

This theme relates to the way time limitations impacted children's opportunities for creative thinking and engagement in sessions. Miss Bird commented specifically on the constraint of time:

> [Of *Bend, Twist, Stretch & Squash*] I wonder if they could go out and actually bend and twist other things in the classroom, not just the things they were given on the table or investigate further those concepts. They did have those extension questions that we could use, but I guess it's just having the time… [Of *Sound Cups*] when we did the telephones, we spent quite a lot of time trying to make the telephones with the children, because it wasn't easy for them to do independently…By the time we made them, we didn't have much time left to experiment with them. But we did say we would put them out for Investigation Time, so we still get to use them.

Reflecting on the afterschool STEM club session, Chloe's dad commented:

> It's just a shame you can't have like, a couple of hours' worth…As opposed to, I think they had what, half an hour? You had that small window where it's really sink or swim. But if Chloe had more time to observe, I reckon she'd really take off with it.

Milly also reflected on time constraints from the perspective of setting up for the shows, and the importance of having enough time as a Science Centre to bump-in for the shows:

> Looking at how like tech set-up and the bumping in of it, like one of the biggest pinch points we had, for both of our shows was just needing the space for the Science Centre operations, but then also needing the space for online delivery. So, the bump-in times were very short, which meant that we were

> always rushing, we could never quite get the right camera set-up or the right lighting set-up to make everything perfect. We just sort of had half an hour to go. So, making sure you have enough bump-in time. Definitely a big one.

Tahlia commented on the importance of allowing extra time for technology during the afterschool STEM club sessions:

> [I suggest] ensuring extra time for the children to log on. And using that time to build that personal connection, asking them questions and maybe breaking the ice with a terrible dad joke. Or even asking them, 'who's that over there, is that your brother? What's your dog's name?' I think that's important in general, but digitally even more so.

4.6.3.3 Getting attention

This theme relates to the challenge that Milly had during the school sessions in terms of getting the children's attention when on screen, and how this differed to being physically in the classroom.

When asked why it took so long to pay attention to Milly at the start of the activity during the *What's in the Cup?* investigation, Jett explained:

> I got distracted by [shaking the cups]. I looked at the computer and when I saw her do that action I did it straight away…Maybe we were shaking [the cups] too hard, there was too much noise.

Similarly, Beth explained they were "busy writing [their answers] down" while Chloe shared, "I couldn't really hear her because the other people there were shaking their shakers."

Chloe felt if Milly had physically been in the classroom, it still would have been too noisy to hear her while Jett believed he would have been able to hear her.

4.6.3.4 Internet connection

This theme addresses the issue of Internet connectivity and the role it played during the Scitech sessions at school and home. The Internet connection worked for the most part. When asked about constraints Miss Bird said:

> The only thing that was a constraint was that the Internet connection was sometimes a bit slower, so there was a delay in their questioning because Milly couldn't ask them straightway.

The potential issues with Internet connection were factored into the delivery by Scitech, with Milly saying:

> Trying to work out how to get the children to explore and investigate without being out of sync with me was an interesting problem we faced. Which is why you might have noticed there's very few times where I counted down with the children. And there's very few times I tried to sync up my actions with the children. That was just because I knew over the Internet, there was going to be a delay, and I didn't want to have that be super obvious or make that distracting for them.

4.6.3.5 Summary of Challenges

The key themes to emerge under the heading of *Challenges* related to the constraints experienced by participants during the school and home-based sessions. Specifically, the limitations imposed by having to send physical materials from Perth to a regional location meant Scitech facilitators felt constrained in the range of creative materials they could provide. Additionally, some of the adult participants felt more time for the STEM activities would have fostered children's creativity further. At times, the Scitech facilitators found it challenging to get the attention of the children due to noise in the room and their inability to physically move into their line of sight. Finally, some minor issues with Internet connections were raised as a challenge which impacted the ability for the children to interact instantly and seamlessly with the Scitech facilitators.

4.7 CROSS-CASE ANALYSIS

A multiple case study design was implemented for this study, to capture the complexity and multiple perspectives of the participating children (Cohen et al., 2018; Stake, 1995). In this project, three case study children each served as an individual case, participating in the online delivery of the Scitech sessions. Drawing upon the observations of the children outlined within this chapter, the following cross-case key findings have been made:

4.7.1 Engagement during the sessions

During their interviews, all three children spoke enthusiastically about the Scitech shows and workshops, stating that they enjoyed participating in them. For instance, Chloe shared how she was now "starting to love science" because of the positive experiences of the Scitech sessions. Beth spoke of how "funny" the *Quiet as a Mouse* puppet show was because of Melody the cat, while Jett shared how he particularly enjoyed the *Bend, Twist, Stretch & Squash* investigation, "because I got to do all the squishing."

This was supported by observations from the Scitech facilitators, classroom teacher, parents, and researcher. For instance, Miss Bird shared of the classroom activities, "They loved it. They were very, very engaged." Although the remainder of the class were incidental participants, their enthusiasm for participating in each of the school-based sessions was difficult to ignore during the observations. This suggests that the content and delivery of the sessions were effective and compelling for a range of children.

4.7.2 Children's experience of online sessions

The consistently positive feedback from the three case children highlights the success of the Scitech program in providing a meaningful and engaging experience. The children at times referred to being online as different in a literal sense, for instance when Beth described, "It felt weird. We could still hear the others even though they're not at our home." However, Miss Bird summarised their experience succinctly by saying, "It wasn't a constraint at all having her not be here in person… They [the children] didn't think it was weird or kind of question that she was on a screen."

4.7.3 Parents' experience of online sessions

The parents of the three children each remarked on the positive impact of the home sessions, not only on the children themselves but on their families. Beth's mum and Chloe's dad both commented on how the afterschool STEM club offered craft-based activities for the children that they otherwise would not do as often at home. For instance, Chloe's dad said, "We're both working full-time, and so with the drop off [of the Scitech kits] it was so much easier." Jett's mum explained how Jett already chooses to engage in construction and craft activities at home, but how he still enjoyed and benefited from the experience. She explained, "After the workshops were finished…he would still keep building and stuff…He's always building."

4.7.4 Varied interests in STEM activities

The varied interests of the children were apparent during the sessions, with each leaning towards different aspects. For instance, Jett was exceptionally engaged with experimenting with slime *(see Narrative 5, Ob 4),* while Beth particularly enjoyed designing her maker shaker *(see Narrative 10, Ob 2)*. Chloe noted how much she enjoyed working with Tahlia and seeing her constructions, sharing, "My favourite part [of *Floating Boats*] was when Tahlia put her boat in the water, and it didn't sink and then she put three or four bolts on it. And then it just sunk down…it was funny!" This highlights the importance of offering diverse range of activities. The diversity helps ensure that children, no matter their interests, find an element that captures their imagination and unique preferences, fostering a more inclusive and engaging learning experience.

4.7.5 Diversity of learning behaviours

The differences in the children's classroom behaviours highlight the diverse ways children engage in learning environments. For instance, during the school-based sessions, both Chloe and Beth consistently worked quietly and independently *(see Narrative 4, Ob 2* and *Narrative 10, Ob 2)*. By comparison, Jett vocalised what he was doing more often, and he engaged in conversations with his peers and Milly frequently *(see Narrative 8, Ob 2)*. Likewise, during the home sessions, Chloe and Beth worked quietly for most of the time *(see Narrative 14, Ob 4)* – although they often talked to their parents in the room with them - with the exception of the first session in which all three children engaged in excited conversations *(see Narrative 12, Ob 4)*. Recognising and accommodating these learning differences and personality traits can contribute to a more positive socio-emotional climate, for instance, by introducing strategic quiet time to help the quieter children focus; asking specific children to share their progress to encourage quieter children to share; and stepping back to allow children to talk and share as they bounce ideas around.

4.7.6 Sharing findings

Jett, more so than Beth and Chloe, enjoyed sharing his findings as he investigated at school. He was often seen calling out to the AV screen and walking over to the AV screen to hold up his recording sheet and designs to share with Milly *(see Narrative 5, Ob 5* and *Narrative 8, Ob 5)*. He would do this unprompted. Sharing findings and forming connections can enhance the learning and creative process, by promoting collaboration, reflection, and the exchange of ideas. The physical proximity of the children's working space with the AV screen made it easy for Jett to engage with Milly.

4.7.7 Lack of focus

There was a notable difference between Jett's learning behaviours and the two girls during the first afterschool STEM club session. While all three were visibly excited, and happily engaged in off-task conversations at times while they worked, both Beth and Chloe remained focused on constructing their houses *(see Narrative 12, Ob 3* and *Narrative 13, Ob 3)*. While they did not finish their houses within the time frame, they were consistently observed working on the task. This contrasts with the experience of Jett, who appeared to find the task challenging and as a result became distracted *(see Narrative 13, Ob 8)*. Tailoring strategies to address individual differences and helping children overcome challenges can help ensure children remain actively engaged and have the best opportunity to meet their creative potential.

4.7.8 Diverse home learning environments

Each child participated in the afterschool STEM club within different home environment (study, playroom, dining room) using a different device (computer, laptop, iPad). Overall, each child was able to successfully participate in the sessions. However, it should be noted that at times it was challenging for the participants to see Jett's face and constructions at the same time due to the positioning of the iPad, and likewise with Beth and the laptop. While it is crucial to consider and accommodate the differing circumstances that children have at home, it is also promising to see how different set-ups still made participation in online learning accessible. Their creativity and participation did not appear to be hindered by their device or location.

4.7.9 Positive socio-emotional climate support

Of the three children, Beth appeared the most hesitant to test her designs, and most nervous or anxious about her designs not being ready or not working *(see Narrative 18, Ob 1)*. Noticing this, Tahlia employed a range of strategies to foster support for her, including testing her own designs first, modelling 'failure,' providing positive words of support to Beth, asking the other children to help count Beth down to launching her egg drop holder *(see Narrative 15, Ob 2)*, and being adaptable to her needs about needing more time. For instance, Tahlia encouraged Beth during the ball run activity by saying, "Did you see mine? Mine all fell off the desk before! It doesn't have to be perfect straight away, you can keep working on it and making it better. It's very rare these things work straight away."

Over the course of the four weeks, Beth showed progress in terms of her confidence and resilience *(see Narrative 20, Ob 5)*. Her mum noted this, "She just got better…she learnt that it didn't have to be a pretty thing. It just had to work…it was about testing. And if it didn't work, it just made you learn something else." Her mum also felt that Tahlia's strategies to support and encourage Beth, "I think it did help, such as when they were doing the ball run. I noticed Tahlia did a ball run and tested it, and it didn't quite go as it was meant to, and it was okay. I think that helped Beth."

This suggests the importance of addressing socio-emotional factors, and how these factors can be achieved in an online learning environment. Creating a supportive atmosphere that encourages risk-taking and learning from mistakes can positively impact children's confidence and creative development.

4.7.10 Ongoing creative development

Both Beth and Jett's parents noted in their interviews that since the afterschool STEM club, their children had demonstrated development in their creative exploration and thinking. For instance, Beth's mum explained how Beth appeared more independent and confident, "Usually when things get hard, she would call me for help. But she's doing it less and less now and very little during the Scitech sessions." Meanwhile, Jett's mum discussed his greater levels of concentration, "[He's going back to previous builds] and making them bigger. So, his one-dimensional builds are turning into three- and four-dimensional." In comparison, Chloe's dad did not observe any meaningful change in Chloe's creative behaviours following the conclusion of the sessions. These responses of parents highlight the individuality of children and the varying impacts of participating in STEM online learning experiences. This further suggests the program's impact could vary based on the existing skills and needs of each child.

4.7.11 Consistent creative processes

The demonstration of all five creative processes by the children throughout the afterschool STEM club sessions illustrates the potential of such a program in fostering creative thinking *(see Narrative 12, Ob 1-4, Narrative 14, Ob 1, 3, 4, 5-7, Narrative 16, Ob 1-3,* and *Narrative 23, Ob 1, 4-5)*. The different creative outputs and ideas of the children further reflect how creativity can manifest uniquely in different individuals.

4.7.12 Small group size

It was observed, and raised in interviews, that Chloe particularly benefited from the small group set-up of the afterschool STEM club. For instance, Tahlia noted that the small group "seemed to really work for her." This was in comparison to Beth, who Tahlia noted in some ways struggled with the smaller group size, as she appeared to benefit from more peer support. However, for Chloe, the small size and home-based location meant it was quieter, and easier for her to focus without distractions. This highlights the potential benefits of the small, online learning experiences and how certain types of learners may thrive in this environment.

4.7.13 Parent collaboration

The parents of all three children engaged to varying degrees throughout the afterschool STEM club sessions. When interviewed, the children and parents spoke positively about this, as did Tahlia. Specifically, Tahlia said, "It was great to be able to experience children being at home and being able to interact with their families… that collaboration with their parents is a very, very special thing." The children were observed sharing their ideas with their parents *(see Narrative 16, Ob 2)*, listening to feedback from their parents *(see Narrative 23, Ob 5)*, as well as their parents becoming involved by helping them *(see Narrative 17, Ob 3)*. Beth's mum and Chloe's dad were observed increasing their involvement over the course of the four sessions.

4.7.14 Summary of cross-case analysis

Overall, the consistent themes among the three children were: their engagement in activities; their enjoyment of activities; consistent demonstration of their creativity online; and their development of creative thinking. They varied most in terms of the ways their creative thinking developed; the strategies that were more useful in supporting their creative thinking; and the ways in which they worked. Observations of the three children's experiences provide insights into the value of accommodating children's learning needs and interests, employing a diverse range of focus strategies and the importance of involving families in children's learning journeys.

4.8 CHAPTER SUMMARY

This chapter has provided a comprehensive description of the findings from the data collected during Scitech's STEM online learning experiences. This data was presented in the form of an overview of the case children's experiences; diagrams of the children's physical learning environments; frequency of communication types, creative moments, and focus strategies identified during multimodal video analysis; narrative analysis of the video data; thematic analysis of the semi-structured interviews with both children and adult participants; and key findings from the cross-case analysis. The qualitative research approach adopted for this study allowed analysis of a range of data sources, which provided comprehensive insight into the experiences and perceptions of the children as they engaged in online learning. Additionally, the multiple case study design allowed for the cross-case analysis, which highlighted the unique experiences, affordances, and challenges of each child during the sessions. This approach has contributed to a deeper understanding of creativity within the context of online delivery, allowing for an examination of the children's experiences be reviewed in comparison to the existing literature around children's creativity. The next chapter discusses these findings in greater detail and how they align with existing literature around children's creativity and online learning.

CHAPTER 5: DISCUSSION

5.1 INTRODUCTION

The previous chapter presented findings from the qualitative data collected during Scitech's ten online STEM sessions. This included an overview of the children's experiences, diagrams of their physical learning environments, a narrative analysis of video data, a thematic analysis of semi-structured interview data, and cross-case analysis of the three case children. The findings illustrated how each child consistently demonstrated creative moments during the school- and home-based sessions, and this was supported by a range of enabling elements within their physical and online environments.

This chapter presents a discussion of the key themes arising from the findings in relation to existing literature. Firstly, the discussion centres around *place*: the elements of an enabling environment (Cremin et al., 2013; Davies et al., 2013b) and the way resources, communication, and socio-emotional climate influenced the children's demonstration and development of creativity. Then, the discussion explores *process*: characteristics of children's creative thinking (Craft et al., 2012; Cremin et al., 2013; Davies & McGregor, 2010; Glăveanu, 2018), and the way children were able to demonstrate the five processes outlined in the *A-E of Children's Creativity* framework (Murcia et al., 2020) as well as moments of mini-c creativity (Kaufman & Beghetto, 2009). Following this, a sixth process of *focus*, which was observed during the study, is considered and discussed.

5.2 PLACE

In the context of the *A-E of Children's Creativity* framework, place refers to the child's learning environment. This section explores themes that emerged during the study in relation to each of the three place elements: resources, communication, and socio-emotional climate. One of the aims of this study was to explore how environmental elements influence children's creativity during online STEM learning experiences. In line with previous research (Davies et al., 2013b; Murcia & Oblak, 2022; Tippett & Yanez Gonzalez, 2022), many enabling elements of the environment were observed during the online Scitech sessions. However, there were nuances to how these elements manifested, given the unique nature of the online delivery. This included: sending physical packs of materials to the children; strategies to gain children's attention; the impact of headphones; and the role of the adult in the room with the children.

5.2.1 Resources

The following section discusses themes around the resource element of the children's learning environment, specifically active learning; familiar resources; intentionality, demonstrations and scaffolding; independent exploration; time constraints; and resource constraints.

5.2.1.1 Active learning

Providing hands-on resources for young children to engage with is understood to be an important component of early childhood learning, STEM education and creative development (Beghetto & Kaufman, 2014; DeJarnette, 2018; Wan et al., 2021). Scitech provided hands-on, active learning opportunities in several different ways over the course of the sessions. For instance, the children were provided with a range of construction materials to create their own DIY shaker during the fourth school-based STEM workshop. Beth demonstrated agency in the way she used pipe cleaners in her DIY shaker design to make it look like a bunny. Similarly, the telephone challenge, which occurred during the *Sound Cups* school-based STEM workshop session, extended the children's daring and problem-solving skills as they explored how to use cups and string in the classroom to make a working telephone. Throughout these hands-on activities, Milly remained present on the AV screen, observing their progress, and offering positive feedback. In this way, there was a consistent connection between the online and offline learning. This intersection was specifically noted by Miss Bird. Reflecting on the *Science is Spectacular!* show and the proceeding *Mini Volcanoes* activity, Miss Bird acknowledged that the children were highly engaged by having the opportunity to take what they learnt from the show and apply it to their own hands-on experiment. These examples highlight the potential for online learning to foster creative thinking, by intentionally providing opportunities for children to be active learners. As well as aligning with the existing knowledge of effective practice in physical early years learning and STEM education environments, this also supports with one of the pillars of effective online pedagogy described by Archambault et al. (2022), and incidental findings about the value of children's agency (Kalogeropoulos et al., 2021; Russo, 2021; Schwartz, 2012). Further, these findings reflect those of Hew (2018) that problem-centric learning and active learning are effective in in engaging university students online. It further extends this understanding, by suggesting that existing techniques for engaging children in physical learning environments could apply to online environments, with the provision of physical materials and an educator facilitating their learning on the screen.

The intersection between the online and offline learning environments was valuable, fostering active learning and creative thinking among all three children. As they watched and listened to Milly and Tahlia deliver through the classroom's AV screen or home devices, the children had regular opportunities to participate with their voices and hands. These opportunities manifested as four distinct types of creative moments: making, experimenting, predicting, and problem-solving. The structure of the activities during the school-based STEM workshops resembled a 'comprehensive approach' to STEM learning, one of the four commonly used approaches in an early years context (Wan et al., 2021). The activities during the afterschool STEM club resembled a 'traditional engineering design' to STEM learning (Malone et al., 2018; Tank et al., 2018), another of the four commonly used approaches in an early years context (Wan et al., 2021). The active learning experienced by the children was a result of Scitech's strategic consideration and planning, to ensure the children were not passive for an extended length of time. As a result, they adapted their in-person delivery model for an online platform by incorporating dialogic conversations and hands-on activities.

5.2.1.2 Familiar resources and connecting

Over the course of their Scitech learning journey, the children actively participated in a range of investigative activities and engineering design challenges that supported their creative thinking. The activities delivered by Scitech intentionally incorporated resources that were familiar with the children. These included common household and construction items that are frequently used in early years face-to-face STEM learning experiences such as pipe-cleaners, al foil, and masking tape (Campbell et al., 2018; Wan et al., 2021). This approach also aligns with the existing approach Scitech uses during their hands-on STEM workshops and incursions.

The decision to use these familiar materials provided an opportunity for the children to draw upon their prior knowledge and make connections, an essential component of the creative process (Murcia et al., 2020). For instance, during the school-based *What's in the Cup* session, all materials concealed inside the cups were common items such as sand, bottle tops, and rice. This approach increased the likelihood of the children being able to accurately identify the contents by leveraging existing knowledge about the weight and sound of those materials. Further, the school-based *Telephone Cups* challenge used the same materials of paper cups, string, and paper clips that the children used in an earlier activity during the same session, however the materials were being applied in a different way. This gave the children an opportunity to draw upon the knowledge they had acquired during the earlier sound cups activity and apply it to a new context. For Beth and Jett, the result was being able to quickly work out how to pull their telephone long and tight across the classroom to make it work effectively, similar to how they had to pull the short string tight when experimenting with their own sound cup earlier. A final example took place during the afterschool STEM club, in which the inclusion of al foil in the *Floating Boats* materials pack allowed Jett to draw upon his prior knowledge that al foil is light and can float – this led to a decision to only use al foil in the construction of his boat.

By intentionally incorporating these familiar resources throughout the different activities, Scitech provided the children the chance to make connections and develop their creative thinking skills. They were able to use materials in different ways, and for a purpose potentially different to its intention. Engaging with Scitech through an online platform did not detract from the impact these physical resources had on the children's learning. This finding further supports the finding that providing hands-on resources to the children is a critical component of successful STEM online learning experiences (Beghetto & Kaufman, 2014; DeJarnette, 2018; Kyere, 2017; Tank et al., 2018). An important finding from this study is that having Scitech facilitators introduce and support the activities via an online platform did not detract from the children's creative thinking or engagement with the materials.

5.2.1.3 Intentionality, demonstrations, and scaffolding

Evidenced in the school and home-based Scitech sessions were the effective use of intentional pedagogical approaches, including educator-led demonstrations and scaffolding investigations. In the context of the school-based STEM workshops, Milly adopted an inquiry-based approach in which she provided explicit instructions about the purpose and process of the investigations. Inquiry-based learning follows a cyclical scientific method of the 5Es: Engage, Explore, Explain, Elaborate, and Evaluate (Bybee, 2010), and incorporates scaffolding by educators (Larkin & Lowrie, 2023). Milly initially engaged the children by providing class demonstrations before the children had the opportunity to explore independently. This was followed by the chance to explain, elaborate, and evaluate alongside their peers and Milly. For instance, during the *Bend, Twist, Stretch & Squash* session, Milly used green-screen technology to project examples onto the background behind her, and used a sample item to demonstrate to the class how to go about bending, twisting, stretching, and squashing. Following this, the children carried out their own independent investigations, while Milly remained on the AV screen to provide feedback and answer questions. This approach aligns with the principles of intentional scaffolding, which has been previously recognised for fostering children's STEM skills in physical classroom environments (Bybee, 2010; Eshach & Fried, 2005; Kallery, 2004).

Although this approach may deviate from the open-endedness of the play-based learning approach advocated in the early years (Bubikova-Moan et al., 2019; Danniels & Pyle, 2018), it does align with the *Framework for School Age Care in Australia* (Australian Government Department of Education, 2022b) and the *Early Years Learning Framework version 2*'s emphasis on, "intentionally scaffold[ing] children's understandings, including description of strategies for approaching problems" (Australian Government Department of Education, 2022a, p. 53). The classroom teacher observed a deep level of inquiry and creative thinking among the children as they engaged in these investigative activities. For instance, she observed that Chloe was more patient with Scitech's investigative activities compared to other classroom activities. This supports the findings of Davies et al. (2013b) who advocate for a balance between structure and freedom, so learners can feel supported while they engage in creative thinking and risk-taking. These approaches were adapted effectively to the online environment. The strategic use of green-screen technology to assist with the demonstration, along with synchronous feedback while the children engaged in their own investigations, illustrates how intentionality and scaffolding can transcend physical boundaries.

Further observations of intentionality occurred during the afterschool STEM club that adopted project-based design challenges. Project-based learning involves children investigating an authentic problem or challenge for a sustained period of time (Lowrie et al., 2017) during which educators help create connections with prior knowledge (Dierdorp et al., 2014). During these sessions, the children undertook sustained engineering design challenges, guided by Tahlia who strategically connected the challenge to real-life experiences and theoretical concepts, to assist the children in creating meaningful products. For example, during the *Egg Drop* session Tahlia introduced the concept of gravity with a balloon demonstration before explaining the egg drop challenge itself. This approach resembles the widely-accepted pedagogical approach of project-based learning that is common in integrated STEM education (Dierdorp et al., 2014; Lowrie et al., 2017). Tahlia's approach also embraced the children's involvement, asking them to predict what would happen when the balloon was dropped and explain why, which reinforces an effective strategy of engaging children in demonstrations. This is an approach advocated by Treagust (2013) who found that students' interest and engagement was increased through demonstrations.

These instances illustrate the value of intentional pedagogical strategies in fostering young children's creativity in synchronous online delivery. They not only align with existing early childhood research around creativity and the engineering design process (Murcia & Oblak, 2022), but also demonstrate the adaptability of these teaching methods to different learning environments. The observation that intentionality and scaffolding retained their positive effects during online delivery indicates the robustness of these approaches and the potential of online learning to provide additional creative learning opportunities for children.

5.2.1.4 Unexpected time for independent exploration

Research into children's creativity illustrates the importance of affording them time and space while educators stand back (Craft, 2003a; Cremin et al., 2006). An unexpected affordance observed during this study was that the online learning environment actively necessitated this 'standing back' due to the physical separation that comes with it. This observation was particularly apparent during the school-based STEM workshops. For instance, Milly was unable to physically go out to the basketball courts and observe their volcano experiments after the *Science is Spectacular!* show. Subsequently, the children returned to the classroom mat the following day, eager to share their discoveries with Milly, who was waiting to hear them on the AV screen. Similarly, Tahlia's approach during the afterschool STEM club strategically aligned with this balance, as she introduced concepts like gravity at the beginning of the session before giving children time and space to work on their own design solutions. This approach resonates with research by Lombardi et al. (2021) who raise the significance of giving learners agency during STEM activities so they can leverage prior knowledge, create and experiment, and engage in hands-on investigation. The temptation that educators in physical learning environments sometimes face to intervene while children are engaged in problem-solving or creative tasks is removed when the learning experience is situated in an online environment. This experience was not only due to the Scitech facilitator being on the screen, but the supportive role of the classroom teacher who was present to provide care, logistical support and assist with fine-motor skills, but not to lead instruction. This is an unexpected affordance the online delivery offers in terms of providing a space that fosters creativity through agency.

Further to this, an affordance of the afterschool STEM club sessions occurring in the children's home meant that they were able to make use of their own resources and continue working on their designs after the session finished. Both Chloe and Beth were observed utilising furniture and objects from around their house to construct their ball runs. Each child chose to continue working on the four design challenges after each session ended. In doing so, this time provided opportunities for the children to continue developing their creative thinking skills. Jett's mum noticed how, after the afterschool STEM club sessions, Jett reflected on the previous constructions he had made at home and chose to make them bigger and more detailed. Similarly, Beth's mum commented on how Beth appeared more independent and confident following the Scitech sessions, calling out for parent help less than she used to. These examples highlight the affordance time and space offered for creative exploration.

5.2.1.5 Time constraints

Cremin et al. (2006) identified that time for creative exploration is an important part of enabling a creative learning environment. A constraint raised during the semi-structured interviews was that of limited time. It was noted by Miss Bird and Chloe's dad that having more time for the children to participate in the STEM activities could have allowed for additional opportunities for creative thinking. This was particularly apparent during the *Sound Cups* school workshop, with the children taking a long time to make the telephones and as such did not have a lot of time left to experiment with them. Miss Bird shared that they chose to put the telephones out later for Investigation Time. This experience highlights not only the constraint of time, but also the consideration of children's fine motor skills as well as the flexibility that can come with making use of STEM activities at later times.

However, the reduced flexibility of online learning poses a unique constraint, for while educators in a classroom may be able to adjust the time of activities as they go, the online sessions run to a more fixed schedule, requiring both parties to be available and connected at the same time. The challenge of time is not exclusive to the online learning environment. In their systematic literature review into STEM education, Wan et al. (2021) found the most frequently mentioned challenge by educators delivering STEM was time constraints. Although the sessions took place online, the sessions were susceptible to the same constraints faced by educators in traditional face-to-face environments. To an extent this normalises the online environment, given one of the few constraints raised by interview participants was related to an established challenge, rather than to a unique challenge presented by the nature of online delivery.

5.2.1.6 Resource constraints

A unique consideration for the online delivery of Scitech's sessions was that of shipping the resources to the school and the children prior to the sessions. Milly discussed how when planning the workshops, the team at Scitech needed to consider the materials required and the feasibility of shipping those materials to the regional location. The consequence of these logistical considerations was having to limit the scope of materials that were chosen. This may have impacted children's opportunities for engaging creatively with stimulating materials (Murcia et al., 2020). It is possible that in a physical environment, the children may have had access to additional resources while completing the same activities, as the Scitech facilitators may have made use of additional materials in their own laboratories or brought them along to an incursion. Access to resources for STEM education has been raised as an issue by educators in traditional, physical classroom settings as well (Jamil et al., 2018; John et al., 2018; Park et al., 2017). While the resource constraints somewhat align with broader trends, there is a unique consideration in terms of fragility, quantity, and weight when shipping materials for an online learning experience.

5.2.2 Communication

The following section discusses themes around the communication element of the children's learning environment, open inquiry questioning; synchronous communication; facilitating dialogic conversation; enhanced viewing experience; and missed responses.

5.2.2.1 Open inquiry questioning

Questioning is regarded as an effective technique in promoting children's creative thinking and problem-solving skills (Cremin et al., 2018). Being curious involves children questioning, imagining, discovering, and engaging in 'what if' thinking. The significance is not on the educator asking questions but asking open-ended questions and providing time for children to consider their responses (Chappell et al., 2008; Craft, 2007; Cremin et al., 2013). Milly was observed questioning the children several times throughout each of the school-based sessions, during class discussions as well as individually during the small group investigative activities. Tahlia also engaged in open-ended questions throughout the afterschool STEM club sessions. These observations suggests that well-established pedagogical strategies for communication may serve well in an online learning context, potentially facilitating a smoother transition for existing STEM educators looking to use online delivery. This somewhat counters a prevailing view that skills for teaching online differ greatly to those in a face-to-face environment (Pulham & Graham, 2018). In the case of this study, the synchronous nature of the live Microsoft Teams and Zoom sessions facilitated the real-time interaction and responsiveness of dialogic conversations, while being projected onto the AV screen meant all children could see Milly and her demonstrations. This strategy ensured that the children could see, hear, and respond to Milly and Tahlia's questioning in a similar way to physical environments.

5.2.2.2 Synchronous communication

Synchronous communication allowed for a range of communication styles to occur throughout the sessions. For example, Milly was able to have a dialogic conversation with the class during the *Quiet as a Mouse* puppet show; Tahlia was able to provide feedback on the children's constructions and coordinate real-time experiments; and the children were able to share their ideas with one another while physically in their own houses. This finding aligns with observations from Fairhurst et al. (2023) who found that communication was an essential element of classroom-based STEM learning environments because of the importance of having capacity to share new knowledge with others. Findings from this study also observed the children enjoying being able to provide feedback and input. For example, the children were seen enthusiastically voting for the balloon animal that Milly was going to make in the *Science is Spectacular!* Show.

Existing research, such as that of Ong and Quek (2023) and Wang et al. (2023), consistently support the advantages of synchronous communication due to its ability to offer instant feedback, improve educator-learner interactions, and promote peer collaborations. The findings of this study not only support previous research on the benefits of synchronous online learning, but also offer a valuable contribution to the field by focusing on a young age group. Previous research into synchronous and asynchronous online delivery during the COVID-19 pandemic suggested it was 'ineffective' for young children (Doz et al., 2023; Russo et al., 2021). As such, these findings point to the potential of young children being able to meaningfully focus and engage in online learning experiences, if those experiences are synchronous in nature. This mode of delivery provides the instant feedback and guidance needed to educate learners of this age. It also aligns with the nature of Scitech's existing shows and incursions, which are dynamic and rely on the input and feedback of young live audiences.

One of the factors contributing to the success of the synchronous interactions during this study was the way participants positioned their devices so others could see their faces and workspaces. This set-up was particularly effective in the classroom environment, where the AV screen in the classroom enabled Milly to see all the children sitting on the mat, as well as allow the children to walk up close to the screen and talk one-on-one with her. Previous research has pointed to small window sizes during online video conferencing as impacting the educator's ability to interact and build rapport with learners (Lakhal et al., 2020). However, this study found that utilising a larger screen facilitated positive educator-learner interactions. Similarly, Tahlia made use of two cameras during the afterschool STEM club sessions so that the children could observe both her face and her constructions. This set-up assisted in them being able to observe and engage in her design process, demonstrations, and experiments.

Finally, the online learning experiences of the afterschool STEM club provided higher levels of accountability compared to asynchronous media like craft YouTube video tutorials with which the children have previously engaged. The children commented on how much they enjoyed participating in the afterschool STEM club sessions, while Beth's mum commented on the benefit of the additional support and accountability received by Tahlia. These comments align with research from Russo et al. (2021), who found that it was challenging to motivate young learners to persist with challenging tasks in asynchronous online learning environments. Given that providing children opportunities to be persistent, daring, and develop solutions to problems is central to creativity, it is valuable to consider the implications of employing synchronous technologies.

5.2.2.3 Facilitating dialogic conversations: Headphones

A unique observation during the study was Chloe's use of headphones during the first two afterschool STEM club sessions and offers new insight into the use of headphones during online learning. Research recommends the use of headphones during synchronous online learning to improve hearing and clarity, as it can minimise interference from noisy surrounding areas (Angelone et al., 2020; Lakhal et al., 2020). However, this current study contradicts previous research regarding young children engaging in online learning. As Chloe was wearing headphones, her dad was unable to listen to the direct instructions Tahlia was giving parents about equipment and safety. At Tahlia's request, Chloe removed her headphones for the third and fourth sessions. Once her dad was able to hear what was being discussed, he was observed becoming more hands-on and involved in Chloe's creative process, helping her experiment and build, as well as engaging in conversations with Tahlia directly. This finding is important within the context of this study, as it identifies a unique consideration for young learners who have often been overlooked in this field of research.

5.2.2.4 Facilitating dialogic conversations: Internet connection

Ongoing efforts have been made to improve the digital divide in Australia, by providing online education access to those living at a distance from major services (Park, 2017). Improving Internet access, through strategies such as the NBN, assists with the successful implementation of synchronous activities. Fortunately, the children participating in this study experienced minimal disruption to the online delivery due to connectivity issues; however, it was mentioned by Miss Bird, Milly, and Jett's mum during their interviews. For example, Miss Bird reflected how sometimes the Internet connection was slower resulting in a delay in asking questions. The impact of unreliable Internet is not exclusive to this study (Fray et al., 2022; Page et al., 2021; Van Bergen & Daniel, 2022), and lag time has previously been raised as a difficulty for learners (Ong & Quek, 2023; Russo, 2021). However, its impact was magnified in this study due to the essential role the Internet played in facilitating seamless synchronous communication between the facilitators and the children. This impact was particularly the case for *Science is Spectacular!* show and

Quiet as a Mouse puppet show, which relied on quick interaction between the facilitator and the children.

5.2.2.5 Intentional learning conversations: Getting children's attention

Both Milly and Tahlia occasionally experienced challenges in getting the children's attention, particularly if the children were deeply engaged in a STEM investigation or if the physical environment around the children was quite noisy. Milly noted how it was challenging not being able to physically move into the children's eye-line to get their attention, and instead, had to develop approaches suitable to the online learning environment. For instance, the 'show me you're listening' strategy, in which they touched different parts of their bodies (i.e., nose, shoulders, head) and the children stopped what they were doing to follow along. They also made use of techniques such as asking the children to give them a thumbs up or hands on their heads, to indicate a response to their questions. These techniques offer solutions to the nuances of delivering to young children online. This challenge also emerged as a common one for educators delivering to young children during emergency remote learning (Soltero-González & Gillanders, 2021; Uzun et al., 2021). However, it should be noted that these studies explored children learning online in the context of a pandemic in which they were at home, often with caregivers who were juggling additional responsibilities, and not necessarily sitting by the side of the child to assist. During this study, the children's parents had set aside time to be present for the activities, and as such were able to assist Tahlia in getting the children's attention if they were absorbed in their task. Similarly, for the school-based activities, the children were in their classroom with their teacher present. The classroom teacher actively assisted Milly in quietening down the children when sitting on the mat as a group. Thus, while gaining children's attention is a known issue in online learning, in the context of this study, the adults in the room provided valuable assistance to overcome this challenge. This highlights the important role the adult in the room plays in supporting the facilitator during online delivery.

5.2.2.6 Enhanced viewing experience

Findings emerged in relation to the viewing experience for the children during the two Scitech shows, *Science is Spectacular!* and *Quiet as a Mouse.* While it was hoped by the Scitech team that the delivery would be comparable with the face-to-face theatre experiences of the shows, it was not anticipated that the online delivery could surpass this method. However, the use of the AV screen to display Milly's shows unintentionally served as an equalising tool that ensured every child had an unobstructed view. This contrasted with the experience the children had when Scitech presented in-person at the school earlier that year as part of their Statewide program. During this incursion, the children were sitting at the back of the hall and were not able to see the experiments in their entirety. Miss Bird commented on how some of the children missed parts of the experiments because of this constraint.

During the online delivery, the use of the camera to pan and zoom to focus attention (i.e., zoom up close to the elephant toothpaste or go 'inside' the bin of dried ice) gave a more detailed perspective of the scientific experiments, enriching the overall educational experience. Similarly, the ability to zoom meant that Milly could do a 'slow reveal' of the *Quiet as a Mouse* puppet show set, resulting in the children being extra surprised when they saw it. Milly explained how this differed to a theatre performance in which children could see the set from the outset, and as a result, lose that 'wow' moment. Previous research in Australia has found that children are engaged by live theatre productions, finding them memorable and enjoyable, which in turn supports children to respond creatively by using their imaginations to plan, organise, and create solutions themselves (Schiller, 2005). Scitech's delivery through an online platform was able to maintain a high level of engagement, as well as offer additional enrichment. Further, previous research has demonstrated how live theatre performances can draw empathy from children who watch them, assisting in turn with their creative thinking (Klein, 1995; Schiller, 2005). During Scitech's *Quiet as a Mouse* puppet show, Beth reflected on how she felt sad watching Racket cry, demonstrating the empathy she felt for the emotional challenges he was facing. It is noteworthy that although the live theatre production was mediated through an AV screen, Beth was still able to form an emotional connection like that which is experienced during live face-to-face performances (Klein, 1995; Schiller, 2005).

5.2.2.7 Missed responses

Despite the affordances of delivering online, the technology did cause occasional moments of confusion. For instance, when Beth called out to Milly that she had finished her DIY shaker and made it into a bunny, Milly initially was unable to tell who was talking to her. Responsiveness is important in children's learning contexts. For example, in the *Early Years Learning Framework version 2,* responsiveness to children is explained in part as, "educators are attuned to, and actively listen to, children so they can respond in ways that build relationships and support children's learning, development and wellbeing" (Australian Government Department of Education, 2022a, p. 21). In this example, Milly being unable to hear Beth and respond to her accordingly, indicates that the technology was a minor barrier in supporting this teaching pedagogy. Existing online learning pedagogies advocate that both educators and learners participate in quiet rooms (Wang et al., 2023); however, this may be challenging in a context such as Scitech's school-based workshops where the children were in the same room as one another, talking, and manipulating materials. This was highlighted during the *What's in the Cup* activity, in which the children were in the same room shaking their cups and unable to hear Milly on-screen. Jett and Beth later explained they were too focused to hear Milly, while Chloe described the room as being too noisy to hear her. The nature of this activity provided positive moments of creative thinking for the children, highlighting the nuances of online delivery in an early years' STEM context, and the need to adapt teaching methods to ensure children hear responses.

5.2.3 Socio-emotional climate

The following section discusses themes around the socio-emotional climate element of the children's learning environment, specifically the positive online experience; the role of the adult in the room; parental involvement; daring and resilience; non-prescriptive learning environments; and time to build connection.

5.2.3.1 Positive online experience

Throughout their interviews, the children consistently shared how much they enjoyed participating in the online Scitech sessions. This was perhaps best exemplified by Chloe's who shared that she is now starting to love science because of her participation with Scitech's sessions. As Miss Bird also described how she didn't feel the screen stopped the children from developing a relationship with Milly. This positive experience is consistent with findings from Tippett and Milford (2017) who assert that carefully designed STEM activities can result in positive experiences for young children, with children demonstrating enthusiasm for learning STEM concepts. As such, this study presents important findings about the potential of online delivery to extend existing face-to-face STEM activities by providing a positive experience that engages young learners' creativity.

5.2.3.2 Importance of the adult in the room

This study highlighted the importance of the adult in the room assisting children during their online learning experience. The role of the adults in this study differed to emergency remote learning, in which caregivers described adopting the role of the educator and often felt stressed trying to juggle multiple responsibilities (Garbe et al., 2020; Negrette et al., 2022). In this study, the Scitech facilitators adopted the role of educator, talking directly to the children most of the time. This was highlighted by the frequency of communication, in which dialogue between adults occurred least frequently and dialogue between Scitech facilitators and the children occurred most frequently. The adults in the room with the children, Miss Bird and the children's parents, were essential in assisting and re-directing the children's focus, moving them around the room for activities and setting up materials, as well as assisting with fine-motor skills. Further to this, the adults in the room were observed enjoying the experiences along with the children and actively participating in the activities at times. Their clearly defined 'support' role meant they did not feel the same pressures or stress felt by caregivers during emergency remote learning. This also aligns with previous studies that found parental engagement had a positive effect on children's achievements in STEM (Ing, 2014; Perera, 2014), particularly when they support and promote key skills such as persistence, attention, and problem-solving (Lang et al., 2014; Milner-Bolotin & Marotto, 2018; Strawhecker et al., 2023). These observations are valuable as a direct contrast to one of the prominent narratives around the challenges of online learning, reframing it as a positive experience.

5.2.3.3 Increased parental involvement

The literature indicates a generally positive and encouraging outcome when caregivers become involved in their children's education process (Ceka & Murati, 2016). This is particularly the case for STEM education, with Milner-Bolotin and Marotto (2018) outlining how hands-on STEM activities provide positive opportunities for families and young children to interact, communicate, and learn together. The structure of the afterschool STEM club sessions provided an opportunity for parents to be actively engaged in their child's STEM learning experiences, occurring in their home at a time they had made available. During these sessions, each of the three children engaged with their parents at different points. For instance, parents were seen listening to their child's ideas, offering constructive feedback, and assisting in hands-on tasks such as holding materials in place during construction. Notably, Beth's mum highlighted the value of the afterschool STEM club, emphasising how it provided her with an opportunity to become more involved in Beth's learning. Further, the advantages of conducting learning experiences in the home extended the practical use of familiar household items, provided the flexibility to continue working on projects in children's own time, and offered convenience to busy parents. This was raised by Chloe's dad, who shared how he and Chloe's mum do not often provide STEM or craft activities at home, making this program a valuable opportunity to engage in this type of activity and learn together. The online delivery provided families physically distant from Scitech's Discovery Centre to experience the positive benefits of working together on STEM activities.

While the children frequently demonstrated their creativity through on-screen communication (i.e., answering questions, sharing their constructions, discussing solutions to problems), there were also instances where creativity was observed through direct communication with their parents. All three children, although Chloe and Beth in particular, would frequently communicate with their parents who were present in the room with them. As the sessions progressed, the two of them communicated with their parents more than they communicated with their peers on-screen. Although the children were engaging in online learning, this did not exclude them from face-to-face communication with their parents. Children were seen having the chance to reap the benefits not only of Tahlia and their classmates on the screen, but also their family members in the room next to them.

5.2.3.4 Daring and resilience

A positive socio-emotional environment was fostered during each of the online sessions by both Milly and Tahlia, which in turn seemed to encourage the children's daring and resilience. Socio-emotional climate incorporates the environment being stress- and pressure-free, non-prescriptive, non-judgemental, and allowing the children to make mistakes (Murcia et al., 2020). This is further supported by Reyes et al. (2012) who noted that classrooms that promote positive classroom emotional climate are more likely to have children who are engaged, enthusiastic, and academically successful.

This was noticeable during the afterschool STEM club sessions, with Tahlia's use of strategies to foster a stress-free environment, encouraging the children's willingness to embrace challenges. An example of this was what she said to Beth when she encountered difficulties with her ball run construction, pointing out how her own experiment failed and how it takes time to get designs right. This supportive comment helped validate Beth's feelings and gave her perspective on the challenge she was encountering. Beth responded positively to Tahlia's words and was observed successfully constructing a large ball run by the end of the session.

Participating in casual conversations and humour, such as the light-hearted exchange about Blu Tack during the *Wind Houses* session, facilitated a sense of belonging and engagement among the children. Similar strategies were employed by Milly during the school-based sessions, such as when she employed humour during the balloon part of the *Science is Spectacular!* show. Additionally, during the shows the children were able to freely express their predictions and make suggestions. They had agency over the design of their DIY shakers, and how they chose to approach independent investigations, and this, in conjunction with Milly's warm and responsive communication, contributed to a positive learning environment. This was evidenced in the way she leant into the camera to listen to the children, always responding with a smile and words of encouragement. For instance, when the children called out that they had successfully created a four-way telephone, she smiled and responded, "Amazing!" This aligns with research that emphasises the importance of educator-learner relationships, particularly in the early years (Davies et al., 2013b). It also supports the understanding that positive relationships are essential during online learning (Borup et al., 2020; Dyer et al., 2018; Garrison & Arbaugh, 2007), and that educators need to create a community in which learners feel connected (Kaufmann & Vallade, 2022; Picciano, 2002). Further, it aligns with findings from Negrette et al. (2022), who suggested that educators need to adapt to the online learning environment and seek strategies for getting to know and engaging young children. While Ong and Quek (2023) found limited physical interaction can pose challenges for building rapport, both Milly and Tahlia demonstrated that through their enthusiastic and friendly personalities, willingness to engage in humour, and show interest in the children, they were able to transcend the online barrier and form meaningful connections.

Tahlia's ability to adapt her delivery style to the online environment played a crucial role in encouraging children who were otherwise hesitant or unsure. By modelling experimentation and demonstrating that making mistakes is acceptable, for example when her ball run broke or boat sunk, she effectively allayed the children's fear of failure. This aligns with existing research, in which Murcia et al. (2022) found that educators modelling behaviours was one of the enabling elements of a creative environment. These strategies had a particular impact on Beth, who was observed as being concerned about failing and very eager to get her designs perfect. Over the course of the four sessions, Beth was seen increasingly testing her designs unprompted and embracing 'failure,' for instance her choice to convert her boat to a submarine after several failed attempts at floating. Beth's mum spoke of the value of Tahlia's strategies in helping develop Beth's confidence, and in turn, her creative thinking. Tahlia spoke of the uniqueness of addressing resilience and daring in an online environment. Notably, she was unable to physically work alongside Beth and assist her with conducting experiments. That was how the strategy of engaging the other two children to help her count Beth down came about. Caregivers commented that they were surprised by the perseverance their children demonstrated during these STEM tasks, noting they were actively engaged in critical thinking, creating, evaluating, and redesigning. The findings from this study align with those of Strawhecker et al. (2023), with the case children demonstrating resilience and daring throughout the STEM activities.

This study offers valuable insights into effective strategies for online delivery, supporting previous research that suggests the use of non-verbal behaviours such as smiling (McArthur, 2022). Milly and Tahlia modelled non-verbal techniques that fostered a positive socio-emotional climate within an online environment. In the absence of being able to physically work alongside a child, they developed strategies for using body language and words to support and encourage, as well as drawing upon support from those who were in the room alongside the children. This was observed in the way they leant into the camera while listening to a child speak, as well as the way they smiled and provided strategic time for the children to work quietly and independently. As the sessions progressed, the children were observed building positive relationships with both educators, leading to them sharing their creative thoughts and designs. This strategic quiet time also provided opportunity for the children to engage creatively with their peers and parents. This in turn had a positive impact on children's creativity and assisted in providing an enriched online learning experience. It also supports the importance of considering non-verbal communication strategies, in conjunction with verbal language, when fostering a positive online learning experience.

5.2.3.5 Non-prescriptive learning environments

Each child was able to meaningfully participate in the afterschool STEM club sessions despite having different home technology set-ups. For instance, Beth used her mum's laptop in the playroom; Chloe used her dad's PC in his study; and Jett worked on his iPad at the dining table. While access to reliable Internet and a device with a camera to support video conferencing was important, there was no one-size-fits all approach to an online learning home set-up. This presents a unique opportunity for broad engagement with online learning experiences in the future, as children need not have any one type of device, or a dedicated room, in which to participate. However, there were times when the placement of Jett's iPad on the dining table meant his face and construction could not both fit on the screen. There were also occasions when siblings came into the open plan living area near the dining table and that did appear to distract him; however, there were also times when they came into the area and were a source of support. These experiences in the home align with research into creativity in a physical learning environment advocating that children have enough space and light in which to work (Bancroft et al., 2008; Vecchi, 2010). Each of the children's workspaces had a combination of both natural and artificial light sources, as well as uncluttered bench space on which to work.

5.2.3.6 Time to build connection

Greater resilience and focus were observed over the course of the four afterschool STEM club sessions. For instance, it was noted that Jett's focus and Beth's resilience increased over the sessions. This indicates the benefit of having more than one STEM session, providing time for Tahlia to foster a positive relationship with the children and make her learning expectations clear. Miss Bird also commented on the value of having Milly deliver several sessions at school, speaking of how this helped build rapport with the children.

The importance of fostering a positive relationship between an educator and learners during online learning has been well-documented (Borup et al., 2020; Dyer et al., 2018; Garrison & Arbaugh, 2007). Along with engaging in age-appropriate humour that the children understood, and participating in conversations, the consistency that Milly and Tahlia appeared on the screen was an important component to their rapport-building with the children. In turn, this assisted the children in feeling comfortable and confident.

5.3 PROCESS

In the context of the *A-E of Children's Creativity* framework, *process* refers to the characteristics demonstrated by children during creative thinking, identified as: agency, being curious, connecting, daring, and experimenting. Additionally, children can display creativity to varying degrees of magnitude, starting with small and personally meaningful discoveries (Beghetto & Kaufman, 2007). This section explores themes that emerged during the study in relation to children's demonstration of creativity.

Throughout their participation in the school and home-based Scitech sessions, each of the three case children displayed all five processes of creative thinking. At times, these resembled what might be observed during a traditional classroom environment, for example posing a question or sharing ideas. However, other instances showcased the nuances of learning online; for example, demonstrating agency by bringing learnings from off-screen back to share on-screen with Milly and Tahlia. Additionally, the children demonstrated moments of mini-c creativity, and a sixth process of *focus* was observed.

5.3.1 Demonstration of processes

Throughout their participation in the Scitech sessions, each of the three children displayed all five characteristics of creative thinking as outlined in the *A-E of Children's Creativity* framework. For example, Jett chose his own material to create his pig character during the *Wind Houses* session (agency). Beth explored the different materials in her ball run kit while imagining how they might fit together (being curious). Jett shared with others and took on different points of view (connecting) when showcasing his egg drop holder during the *Egg Drop* afterschool STEM club session. Beth demonstrated her ability to persist and tolerate uncertainty (daring) when she converted her boat into a submarine during the *Floating Boats* afterschool STEM club session. Finally, Chloe tried out new ideas and used materials differently (experimenting) when she manipulated the various items provided during the school-based *Bend, Twist, Stretch & Squash* investigation. These observations align with Bers et al. (2019) observation of children's creativity while coding, in which they were found to use materials "in a divergent, unexpected manner" (p. 139). This was similarly evidenced in the way the children of this study approached the various challenges.

The children's demonstration of the creativity processes resembles that of children in classroom-based STEM activities. For instance, Tippett and Yanez Gonzalez (2022) also observed all five processes of creativity in young children participating in STEM activities at an early learning centre in Canada. Meanwhile, Murcia and Oblak (2022) observed characteristics such as being curious, connecting, and experimenting in young children participating in engineering design challenges at an early learning centre in Australia. To have observed children demonstrating these processes in similar ways online highlights the potential for extending STEM learning experiences to children in regional and remote areas through online delivery.

5.3.2 Mini-c creative moments

Another observation during the children's participation in the Scitech sessions was the way the activities lent themselves to 'incidental' mini-c creative moments. The mini-c level of creativity addresses new and personally meaningful interpretations, ideas and insights (Beghetto, 2007; Kaufman & Beghetto, 2009). This was illustrated during the afterschool STEM club sessions, for instance during the *Floating Boats* session. Through tinkering and experimenting with different shapes for his boat, Jett discovered that a canoe shape floated most effectively. While this is not a unique boat design, it was an important discovery for Jett and greatly assisted with the success of his product.

Tahlia and the Scitech team created the four sessions as design-based engineering challenges, in which *making* was the predominant creative moment planned for. This is a common approach in early years face-to-face STEM experiences that Wan et al. (2021) found in their systematic literature review into early years STEM education. They noted this approach allowed children to be daring and ultimately construct a tangible product that solves a problem. Similarly, Tank et al. (2018) observed young children as they designed a paper basket to transport wet and dry rocks using the engineering design process. Additionally, the activities in this study afforded opportunities for the children to demonstrate creative moments of experimenting, predicting, and problem-solving. In order for the children to successfully construct their house, egg holder, ball run, and boats, they consciously chose to experiment (i.e., test if the ball will fit through the pipe before adding it to their construction); predict (i.e., will the boat float if I make it this shape?); and problem-solve (i.e., how can I slow down the speed of the egg as it falls?). Tahlia frequently encouraged these incidental moments of creativity, by posing questions or asking them to predict what would happen before her own experiments. The children's parents were also observed encouraging them to experiment and problem-solve. There were instances in which the children independently chose to experiment, predict, and problem-solve. This aligns with the assertions of Van Meeteren (2015) that young children can demonstrate persistence and determination when constructing designs such as ball runs and ramps. It indicates how similar levels of determination and focus can be present during online delivery of STEM learning experiences.

It could be problematic to overemphasis the product during the creative process, as it fails to acknowledge creative potential and children's personal efforts (Beghetto & Kaufman, 2007; Runco, 2005). During the Scitech sessions, the children undertook activities that emphasised both the product and the process. Specifically, through the creative moments of experimenting, predicting, and problem-solving, the children's focus was as much on the creative process as it was on the final product. This was also exemplified during the school-based STEM workshop activities of *Bend, Twist, Stretch & Squash, Sound Cups* and *What's in the Cup?*, in which the emphasis was on the processes of investigating, predicting, and experimenting rather than developing a final product.

Although physically separate from the children, Tahlia and Milly were able to provide an environment in which the children had the opportunity to demonstrate a broad range of creative skills. The structure of the sessions, the focus on exploring and experimenting, the tangible resources, and the encouraging feedback all provided a space in which the children could demonstrate different creative moments and foster mini-c creativity.

5.3.3 Greater opportunity for predicting

While the children demonstrated the creative moment of *predicting* throughout the Scitech sessions, this skill was the least observed compared to the other three types of creative moments. It occurred most often when the children were prompted by Tahlia or Milly, and it was rare to see the children independently predict, although they were observed independently experimenting. Predicting occurred almost half the amount of the time as experimenting.

Predicting is embedded within the Australian Curriculum for Science inquiry (ACARA, n.d.-a). It also provides a chance for children to question, imagine, and make connections. While Falloon (2016) suggests that a fixation on predicting could slow down children's overall progress and should be balanced with taking risks, there is nevertheless the potential for future online delivery to encourage greater opportunities for this creative moment. This might involve the facilitators prompting children to predict what they think will happen before each child experiments with their constructions, rather than just before the facilitator tests theirs.

5.3.4 Focus

An unexpected finding in this study was the way children demonstrated an additional creative process of *focus* while engaging in online STEM activities.

5.3.4.1 Children demonstrated creative thinking while focused

While five processes of creativity have been identified in the *A-E of Children's Creativity* framework, this study points to the inclusion of an additional process within the online learning environment. The characteristic of *focus* has not been extensively discussed in the context of STEM and creativity, although Tippett and Yanez Gonzalez (2022) briefly noted they saw instances of 'flow' in children engaged in STEM activities at a Canadian early learning centre. Flow is a described as the state of being fully focused and immersed in the creative process (Nakamura & Csikszentmihalyi, 2002). Further, researchers have also pointed to the connection between children's attention and its links to creativity (Cremin et al., 2013; Martindale, 1999).

Throughout the episodes in this study in which the children demonstrated focus, they were also visibly engaged in the STEM learning experiences. This included actively constructing their designs, developing solutions, as well as experimenting and investigating with materials. In contrast, instances where the children were not exhibiting indicators of focus coincided with them being off-task, and other process characteristics of creativity were observed less frequently. Exemplifying this was Jett's participation during the *Wind Houses* afterschool STEM club session. Half-way through this session Jett's concentration began to wane, which ultimately led to him engage with other objects and toys around his house. Although his focus was directed back to the STEM challenge by Tahlia and his mum, the result of spending so much time off-task was that he had insufficient time to tackle the complex challenge of building his house. This aligns with growing understandings that children's engagement and concentration are a prerequisite for successful learning (Fisher et al., 2014). The presence or absence of the focus process ultimately shaped the level of engagement, completion, and creativity of the children in participating in the STEM online learning experiences.

5.3.4.2 Focus indicators

This study revealed several indicators associated with the process of focus. These were: active learning, absorption, attentive listening, clarity, and concentration.

Active learning as an indicator of focus involved the children absorbing information and actively engaging in the learning process to create new ideas or products. Active learning is widely understood as an effective pedagogical strategy in fostering children's creativity in physical environments (Beghetto & Kaufman, 2014; DeJarnette, 2018). It has also been identified as an important consideration in effective online learning, and emerged as an successful strategy with young children engaged in emergency remote learning (Archambault et al., 2022; Dayal & Tiko, 2020; Soltero-González & Gillanders, 2021).

Absorption as an indicator of focus involved the children demonstrating high levels of engagement and immersion in the STEM activities. At times, the children were absorbed to the extent that they did not hear when Milly or Tahlia were trying to gain their attention; they lost track of time; and requested more time to continue working on their activities. Further evidence of the children's absorption was that Beth, Chloe, and Jett all chose to continue working on the four afterschool STEM club challenges once the online sessions ended. Evidence from previous studies suggest that additional time and attention can contribute to more detailed STEM solutions (Cremin et al., 2006). This also aligns with the understanding that children's creativity is encouraged when they have time for creative exploration and display self-determination (Cremin et al., 2006; Davies & McGregor, 2010). This process could be further understood as resembling engagement or flow. Engagement is described in the *Framework for School Age Care in Australia* as being "associated with attention, curiosity, interest, optimism and active involvement in learning" (p 65). Similarly, flow is understood as the state of being fully focused and immersed in the creative process (Nakamura & Csikszentmihalyi, 2002). While these two terms could be used to describe this process, the term *absorption* was selected as it aligned suitably with the actions observed of the children.

Clarity as an indicator of focus involved the children purposely directing their creative thinking towards the STEM challenges and activities. As a demonstration of clarity, the children were seen having clear intentions about what they were doing or trying to achieve. For instance, while designing her maker shaker, Beth did not deviate from the task of constructing a working shaker despite her enthusiasm for making it look like a bunny. Likewise, although Jett enjoyed experimenting with the water and psyllium husk during the slime activity, he remained determined to create the right consistency for slime.

The children were also observed developing greater clarity around the design-based engineering challenges of the afterschool STEM club. For instance, it was observed by Tahlia that, as the children became familiar with the materials included each week in their packs, they were able to focus their creative thinking on the design challenge, rather than on how to manipulate the materials themselves. Further, Beth's mum felt that Beth developed greater clarity over the four weeks, becoming better at focusing on the construction part of the challenges, rather than the aesthetics. This is reflected in Beth's creative outputs, a large-scale ball run and successful boat-turned-submarine in the final two weeks, compared to the half-built house of the first week. Beth's mum stated in her interview how Beth got better at constructing a working design as opposed to a pretty one. Although focus was not the only contributing factor to Beth's creative development, her improved clarity appeared to assist.

Concentration as an indicator of focus involved the children demonstrating mental effort and undivided attention, resulting in them being fully engaged with the STEM activities. During the school-based *Sound Cups* activity, there was a moment in which one of the other children around the table became off-task and began flipping cups off the table. Jett and Beth quickly copied and in doing so, stopped engaging in the investigative task. Milly re-directed them to the task by asking them to demonstrate to her the different sounds their cups could make. The next time the other child began flipping cups, both Jett and Beth ignored him and continued with their investigation. Jett was observed having discovered unique ways to make sounds that no one else had done. Likewise, during the afterschool STEM club sessions, the children displayed concentration at different times. For instance, Chloe appeared to concentrate on her constructions for most of each session, briefly engaging with the other children when they called out to her, before quickly returning to her task. This concentration contributed to her completing her ball run design during the session, resulting in one of the best ball runs Tahlia had ever seen. These examples illustrate how when the children were concentrating on the STEM activities, and not giving attention to the distractions around them, they were able to put more energy into their creative thinking.

Attentive listening as an indicator of focus involved the children participating in conversations and collaborations. For instance, during the *Quiet as a Mouse* puppet show, Beth was seen to be engaged with Milly's performance through her attentive eye gaze, body language, and listening skills. Even when there were distractions in the room around her, for instance other children fidgeting, talking, or moving around, she continued to attentively listen to what was happening in the show. This led to her sharing a creative solution to Racket's problem that his neighbour, Melody the cat, wear headphones instead of him being quieter.

Eye gaze is a common measure of visual and auditory attention (Fisher et al., 2014). Miss Bird commented that Beth did not always listen by maintaining eye contact during regular classroom activities, but that she did for all of the school-based Scitech sessions. It is understood that communication is essential in helping foster creativity (Beghetto & Kaufman, 2014; Cheung & Leung, 2013; Haney et al., 2002; Richardson & Mishra, 2018), and thus the children engaging in attentive listening presents a positive foundation upon which intentional learning conversations and questioning can occur.

5.3.4.3 Online learning environment offered greater opportunities for focus

It was noted that the online learning environment during the afterschool STEM club sessions provided a positive environment in which to focus. This was particularly the case for Chloe, and supported by observations from her dad, Beth's mum, and Tahlia. Chloe felt that it was easier to concentrate during the online sessions, as it was a smaller group and much quieter than the classroom. She noted that when the others were loud and she was working on something particularly challenging, she found it difficult to focus. This was supported by Miss Bird's comments that Chloe was sometimes distracted in the classroom when her brother was sitting near her. This was an unexpected finding, given research during emergency remote learning found that distractions around the home were an issue and barrier to children's learning (Dong et al., 2020b). Chloe's experience highlights the affordance small group online sessions could offer some children, by providing a space in which they can work creatively without additional distractions.

5.4 CHAPTER SUMMARY

This chapter has presented a discussion of the key themes that emerged from the findings of the study in relation to existing literature. Firstly, the discussion centred around the elements of an enabling environment, exploring how many of the pedagogical approaches adopted during STEM activities within physical learning environments were adapted to the online learning environment with positive outcomes. Specifically, providing children with familiar, physical materials to engage with intentionally, with the support of demonstrations and scaffolding are frequent teaching approaches that provided the children of this study with opportunity for creative exploration. These findings built upon existing literature, demonstrating the way classroom pedagogical approaches can translate to an online space. Additionally, the synchronous nature of the Scitech sessions allowed the children to engage in dialogic conversations and answer questions, which fostered their creative thinking. This supports existing research that demonstrated the benefits of synchronous delivery. Similarly, the minor disruptions caused by Internet connectivity issues were reminiscent of previous accounts of online learning experiences. In contradiction with previous research was the use of headphones, which were found to hinder parental involvement during the afterschool STEM club sessions. An unexpected affordance was the enhanced viewing experience for the children while engaging with the Scitech shows, advancing our understanding of the benefits online delivery can offer young children. The discussion also explored how the children enjoyed a positive socio-emotional climate, and the affordances of increased parental involvement during their learning which supports existing insights into the important role caregivers play in their children's education. This has furthered understanding of the ways children's creativity can be positively fostered within an online learning environment. Following this, the discussion outlined how the children were able to demonstrate the five processes of creativity as well as instances of mini-c creativity. This has expanded awareness of children's capacity to demonstrate creativity, indicating they can still demonstrate their creative thinking within an online learning environment. Of the four types of creative moments observed, predicting was observed least frequently, suggesting how future online STEM learning experiences could strategically encourage this skill. Finally, a sixth process of creativity, focus, was observed in the children. This observation suggests the potential benefit of extending the existing *A-E of Children's Creativity* framework to include the additional process. Such an inclusion would expand our understanding of how to observe children's creativity. The following chapter presents the conclusion to the thesis, where further exploration of this implication is explored.

CHAPTER 6: CONCLUSION

6.1 INTRODUCTION TO CHAPTER 6

The previous chapter discussed the findings presented in Chapter 4 in relation to the existing literature. Previous research has identified suitable pedagogical strategies for older online learners, as well as fostering young children's creativity within a physical STEM learning environment. However, little is known about how to foster young children's creativity within a STEM online learning environment. This study confirmed that young children have the potential to demonstrate the same range of creative process online as in-person, and how existing classroom pedagogies can translate to online delivery. Further, the study identifies how existing online learning pedagogies can be applied and adapted for young learners.

The rationale for a multiple case study approach was to explore and analyse the experiences of young children, acknowledging through a constructivist paradigm that each child will construct their own reality. This study involved observing three case study children as they engaged in ten online STEM sessions delivered by Scitech, Western Australia's leading science discovery centre. Multimodal video analysis was conducted, providing insight into the ways children's creativity was both demonstrated and supported. Additionally, semi-structured interviews gave the children the opportunity to provide first-hand accounts of their experiences. The inclusion of adult participant interviews provided a range of additional perspectives, adding depth to the understanding of each case child. Finally, diagrams of the children's physical learning environments provided insight into the impact of their physical space on their creative thinking and engagement with online delivery.

This research is significant because it provides a valuable contribution to existing literature around children's creativity, online learning, and STEM education. With a growing emphasis of accessible learning opportunities, particularly for children in regional and remote areas, it is crucial to identify effective online pedagogies. Additionally, with creativity embedded in international policies and guidelines as key competency, there is a need to understand how best it can be fostered. This study contributes meaningfully to existing literature by demonstrating the potential of young children's creativity to be fostered in STEM online learning environments, as well as practical guidelines for STEM online educators. It also highlights unique affordances that the online delivery offered, including an enhanced viewing experience and additional support from parents, which supported children's creative engagement with the STEM activities.

This chapter begins with answering each of the study's research questions, before presenting the practical guidelines for STEM online educators. Following this is a discussion of the limitations and significance of the study, recommendations for future research, and concluding remarks.

6.2 ANSWERING THE RESEARCH QUESTIONS

The following section provides answers to the study's research questions.

6.2.1 Research question 1

The aim of this study was the explore fostering children's creativity with STEM activities in online learning environments. Consequently, the first research question driving this study was:

How do environmental elements influence children's creativity during STEM online learning experiences?

In response to the question, the environmental elements impacting the children's creativity during this study were: resources, communication, and socio-emotional climate (Murcia et al., 2020). In terms of resources, those used during Scitech's STEM online learning experiences were found to be conducive to children's creativity when: physical resources were provided so children could actively participate in the learning; familiar resources were chosen which allowed children to draw upon existing knowledge to make connections; and intentional provocations, demonstrations, and scaffolding were provided by the Scitech facilitators to guide children's investigative thinking. Further, it was found that the online delivery afforded additional time for creative exploration by requiring Scitech facilitators to 'stand back' and give children space to be creative independently and provide opportunities for children to continue working on activities in their own time. As with classroom-based STEM lessons, the online delivery was impacted by time and resource constraints.

In terms of communication, the Scitech facilitators implemented strategies that encouraged children's engagement and creative thinking. Specifically, open inquiry questioning was found to be effective as it is in physical learning environments; the use of synchronous communication in the form of Microsoft Teams and Zoom sessions allowed creativity to be fostered through dialogic conversations and positive teacher-child relationships; the use of headphones were ineffective as they prevented the caregiver from hearing and engaging in the session; a stable Internet connection was crucial to providing seamless communication, particularly during Scitech's shows; intentional learning conversations required the facilitators gaining the children's attention, which was challenging at times; and communication was hindered occasionally because the facilitators were unable to tell which child had been speaking. Finally, an unexpected affordance of the online delivery was an enhanced viewing experience during the school-based shows due to the ability to zoom in and out on moments of importance.

In terms of socio-emotional climate, the Scitech facilitators were able to implement strategies that helped the children feel confident and creative online. Adults interviewed in this study commented that the children demonstrated the same, if not greater, levels of creativity than they had previously shown in the classroom or home. The environment included the adult physically in the room with the children and they were essential in helping to get the child's attention, directing the child to activities and for fine-motor skill support. Educators' positive non-verbal communication fostered rapport and a safe learning environment. An affordance of the afterschool STEM club was the increase in parental involvement in their child's learning. The Scitech facilitators used encouraging words and demonstrated their own experiments and 'failures' to help develop the children's daring and resilience. The children's home learning environment could include different technology devices and spaces and still result in a positive experience. Finally, an extended period of time and numerous sessions with the same Scitech facilitators assisted in building a positive relationship between them and the children.

Overall, this study found that a combination of existing elements known in physical learning environments, with important modifications to accommodate the nuances of the online environment, positively impacted children's creativity. These modifications included sending children familiar resources so they could actively engage in the activities; making use of synchronous online platforms without headphones to stimulate real-time communication; engaging the support of the classroom teacher and parents to support children's learning; employing focus strategies to get the children's attention while they were busy with hands-on activities; and increasing non-verbal communication strategies to assist with the development of rapport and trust.

6.2.2 Research question 2

In relation to creativity, the second research question driving this study was:

In what ways do children demonstrate creativity while engaging in STEM online learning experiences?

In this study, children's demonstration of creativity aligned with the five creative process indicators outlined in the *A-E of Children's Creativity* framework, that of agency, being curious, connecting, daring, and experimenting. This study found that the children were able to demonstrate all five processes of creative thinking during the STEM online learning experiences. The online learning environment also afforded opportunities for mini-c creative moments. Findings showed less moments of predicting, which could have assisted in furthering children's creative thinking. An unexpected way the children demonstrated creativity online was through the process of focus which took the form of the following indicators: active learning; absorption; clarity; concentration; and attentive listening. The study also revealed that at times the synchronous online learning environment afforded opportunities for focus that the classroom or asynchronous YouTube videos did not.

6.3 SIGNIFICANCE OF THE STUDY

There are several implications for the findings from this study, which are significant to Scitech and the case children who participated, as well as educational research and stakeholders more broadly.

6.3.1 Contribution to fields of research

Although several of the pedagogical strategies used effectively during this study align with findings from previous research into STEM and online learning, it is important to note that earlier studies were focused on older students or physical delivery to young children. No previous studies have looked at the specific context of creativity and young children learning STEM online. Thus, the significance of this study is its identification of processes that actively foster young children's creativity through STEM in online learning environments. Not only does it fill a significant gap in the international body of research literature, but it also advances understanding on how to further STEM education and foster creativity in children.

This in turn, supports national and international STEM online educators to implement online delivery, which provides benefits for children's creative development. Online delivery provides the potential for children to access learning experiences from qualified educators. The significance of this study has been its focus on developing guidelines for quality practice in this space, which assists in children's positive learning experiences and fostering of creativity, as set out in section 6.4.

6.3.2 Additional process of creativity

An additional process of children's creativity emerged from observations, that of *focus*. This distinctive characteristic presents a novel and valuable contribution to understanding of children's demonstrations of creativity in an online environment. Thus far, focus has not been explicitly explored or included in observations of young children's creativity. It was briefly alluded to by Tippett and Milford (2017) in their discussion of creativity in STEM at an early learning centre in Canada. Similarly, while attention, flow, and concentration have been identified as important states for academic achievement, there is little academic literature to connect them with creativity in young children. The findings from this study around the observation of focus is illustrated by the researcher's proposal to amend the *A-E of Children's Creativity* framework to the *A-F of Children's Creativity* framework, to acknowledge this process. Its inclusion will assist educators in providing opportunities for focus among children when engaging in online creative thinking, for instance through introducing specific 'quiet times' so children can focus. The researcher's proposed amendment to the framework is represented in Figure 6.1.

Figure 6.1

Proposed A-F of Children's Creativity framework

PRODUCT: Criteria for creative outcomes	
Original	Fit-for-purpose

PERSON: Perspectives on who does the original thinking		
Child engaged by educator's creativity	Child's creative doing	Child's creative thinking

PLACE: Elements of an enabling environment		
Resources	***Communication***	***Socio-Emotional Climate***
• Intentional provocations • Stimulating materials • Adequate materials for everyone • Time for creative exploration	• Intentional learning conversations • Hearing and valuing children's ideas • Open inquiry questioning • Facilitating dialogic conversations	• Stress and pressure free environment • Non-prescriptive • Non-judgemental • Allowed to make mistakes

PROCESS: Characteristics of children's creative thinking					
Agency	***Being Curious***	***Connecting***	***Daring***	***Experimenting***	***Focus***
• Displaying self-determination • Finding relevance and personal meaning • Having a purpose • Acting with autonomy • Demonstrating personal choice and freedom • Choosing to adjust and be agile	• Questioning • Wondering • Imagining • Exploring • Discovering • Engaging in 'what if' thinking	• Making connections • Seeing patterns in ideas • Reflecting on what is and what could be • Sharing with others • Combining ideas to form something new • Seeing different points of view	• Willing to be different • Persisting when things get difficult • Learning from failure (resilience) • Tolerating uncertainty • Challenging assumptions • Putting ideas into action	• Trying out new ideas • Playing with possibilities Investigating • Tinkering and adapting ideas • Using materials differently • Solving problems	• Active learning • Absorption • Clarity • Concentration • Attentive listening

In the figure, the five indicators of focus are listed: active learning, absorption, clarity, concentration, and attentive listening.

6.3.3 Additional consideration for communication (silence)

While all the indicators of the communication element from the *A-E of Children's Creativity* framework were observed throughout the children's Scitech learning journey, an additional element was observed, that of *silence*. This study revealed that online communication that encouraged children's creative thinking also benefited from moments of silence in which conversations were not actively encouraged. This strategic quiet time, facilitated by the Scitech facilitators, provided the children with time to focus on their investigations, experiments, problem-solving, and constructions. Unlike a traditional classroom or workshop environment, in which educators can speak quietly one-on-one with children without disturbing the others, or children could move to a quieter part of the classroom, the afterschool STEM club lacked this dynamic due to the nature of the Zoom meeting. It meant that everyone could see and hear each other equally. This is a valuable observation, given the importance of communication as a creativity enabler. Understanding the importance of quiet time can assist online educators in structuring their STEM learning experiences, helping them understand the importance of stepping back and letting children work quietly.

6.3.4 Scitech outreach

It is a promising outcome of this study that all participants were unanimous in wanting to engage in more Scitech online learning experiences. Adult participants spoke of how worthwhile it would be for Scitech to offer an online outreach program to complement their existing Statewide program, as well as offer an online afterschool STEM club. They noted the opportunity to foster stronger relationships with communities and schools by connecting more frequently. Currently, Scitech connects with regional and remote schools every three to five years. However, online delivery presents a unique opportunity to deliver consistent, high-quality STEM education to children in regional areas more consistently and frequently. Additionally, online delivery offers the potential for children who are unable to attend Scitech due to health, disability, or who are home-schooled, to engage in STEM online learning experiences. This offers unprecedented opportunities for accessibility and inclusivity.

Following their involvement in this study, the participating regional school contacted Scitech to discuss continuing an online program. Accordingly, Scitech delivered an afterschool STEM club to the school in 2023, which was the first of its kind in Western Australia. The participating students remained in the ICT Lab after school with Scitech facilitators projected onto the AV screen. This program made front page news of the local newspaper, highlighting the significance of this program for children in the region (see Appendix 21). The significance of this delivery model is that it could inspire other education providers, both nationally and internationally, to explore similar models to deliver their own STEM learning experiences to children who cannot visit them physically.

6.3.5 Re-framed perception of online learning

The findings of this study illustrate the potential of creative STEM education occurring through online delivery to young children. This presents significant potential for extending education outreach to children regardless of their physical locations, as well as decrease the financial and logistical impact on STEM education services, such as Scitech, to increase their physical travel to regional and remote areas. As a result, children in these areas could have the opportunity to engage in STEM education on a regular basis, alternating between face-to-face and online delivery. There are also implications from this study that could be of benefit to existing distance education institutions, who seek quality practice for increasing engagement and creative thinking.

Ultimately, the findings from this study contrast with some of the research findings that gained traction during the COVID-19 pandemic, namely that online learning is “boring” and “passive” (Dong et al., 2020b, p. 7; Inan, 2021, p. 7). This constrast raises the importance of context: the current study explored the potential of intentional online delivery in which children participated in STEM outreach activities while physically in a classroom or home environment with a supporting adult present. This is a starkly different context to children engaging in emergency remote learning at home through a hybrid of synchronous and asynchronous activities. The current study helps re-frame the perception of online learning, recognising that it has the potential to be engaging, dynamic, and foster positive outcomes for young learners.

6.4 GUIDELINES FOR FOSTERING CREATIVITY IN YOUNG CHILDREN THROUGH STEM ONLINE LEARNING EXPERIENCES

An important outcome of all research is its ability to progress knowledge and affect real world change. Accordingly, Table 6.1 details considerations for STEM online educators when delivering online learning experiences to children. STEM online educators could include those delivering online STEM activities through distance education, as well as facilitators from science discovery centres, galleries, libraries, or museums. Specifically, the elements of technology, resources, communication and socio-emotional climate need to be considered, to provide an environment conducive to fostering young children's creativity.

Table 6.1

Guidelines for fostering creativity during online learning experiences

Elements	*Considerations for online educators*
Resources	- Ensure time is factored in for technology to be tested and set-up - Have the same materials in your workspace as the children so you can demonstrate and create alongside them - Consider activities and materials that are age-appropriate to maximise time for creative exploration - Provide adults with a list of suggested materials to source prior to online sessions - Encourage adults to allow additional time for creative exploration following the conclusion of online sessions
Communication	- Use a 'get attention' strategy that incorporates visual and auditory elements - Provide quiet time so children can focus on their creative tasks - Ask adults to ensure the room is not too bright so AV screen is visible - Ask adults to mark out space so children sit within view of the camera - Ask adults to set the child's device to gallery view mode so they can see other participants - Ask children not to where headphones so their supporting adult can hear your instructions - Use two cameras during sessions: one pointed at your face and the other pointed at your workspace
Socio-emotional Climate	- Join the online session early so you have time to build rapport with the children - Address children by name during online sessions - Consider ways for children to actively participate in the classroom alongside your online delivery - Consider small online group sizes, or rotating small groups, to ensure time with all children - Provide adults with clear expectations about how you would like them to assist the children during the online session

These guidelines offer practical considerations for online STEM educators when preparing and delivering online learning experiences to young children. Following these guidelines could help establish an online learning environment that fosters the creativity of young learners. Consequently, regardless of their physical location, young children would have access to quality online learning experiences that provide meaningful opportunities for them to engage in creative thinking.

6.5 RESEARCH LIMITATIONS

Details of the research method limitations were outlined in Chapter 3. These limitations related to the small number of cases included in the study; the timing of the follow-up interviews; and the children's pre-existing interest in Scitech, science, and STEM. This section outlines broader limitations of the study in terms of generalisability; transferability; researcher bias; and learning outcomes.

6.5.1 Generalisability

This study adopted a multiple case study approach, with three children serving as each case. As with case studies in general, the findings from this study may not be replicable, representative or generalisable (Cohen et al., 2018). It is acknowledged that this study's findings may not be applicable to other contexts, as the findings are specific to the chosen location of a regional Western Australian school, with Year 1 children who were previously enthusiastic about science, STEM and/or Scitech, who chose to engage with Scitech's online sessions. Applying the findings and guidelines from this study to other cultural, geographical, or larger cohort contexts should be done with caution.

6.5.2 Transferability

These findings may be transferable to other contexts in which Scitech specifically, as well as similar science discovery centres, deliver synchronous sessions online to young children in locations where the children are previously familiar with the science discovery centres' sessions. These findings may be transferable to other online learning contexts, such as distance education, in which the educator is delivering content that is STEM-based, or where one of the learning objectives for an activity is creativity.

6.5.3 Researcher bias

It was acknowledged during this study that an interpretive epistemology understands that human experience is subjective, and qualitative data is a constructed interpretation. While every effort was made to ensure the validity of the findings, they ultimately represent the researcher's interpretation of the data. By offering as much detail as possible about the research process, there is a degree of confidence that the presented findings closely align with reality.

6.5.4 Creativity as the outcome

The focus of this study was to explore how the key competency of creativity could be fostered during online learning experiences. The study was not focused on the academic outcomes of the children as they participated in Scitech's STEM activities. As such, the positive findings reported here relate to the development of children's creativity, not necessarily their increase in STEM knowledge, skills, or academic results. Applying the findings and recommendations from this study to an online learning context seeking academic outcomes should be done with caution.

6.6 RECOMMENDATIONS FOR FUTURE RESEARCH

While this study has meaningfully furthered understanding of children's creativity in online learning environments, there remains opportunities and considerations for further research.

6.6.1 Broader learning areas

This study focused specifically on STEM-based activities delivered by a science discovery centre. As such, it did not explore how arts-based subjects such as Visual Arts or Humanities and Social Sciences could provide ways of engaging children creatively. Future research could observe children in a similar way to this study, with facilitators drawing upon integrated science, technology, engineering, arts and mathematics (STEAM) or arts disciplines. This further research may reveal innovative ways of enhancing the online learning experience, as well as fostering young children's creativity.

6.6.2 Children with diverse backgrounds and learning needs

This study did not seek to gather a representative sample of children from a range of backgrounds or with diverse learning needs. As such, it cannot offer insight into the impact of online learning experiences on children with learning difficulties or English as a second language. Examining barriers to accessing online learning and identifying strategies to address inclusivity gaps to ensure children of all needs and backgrounds can develop their creativity would contribute to equitable educational opportunities. This examination could also include comparing the experiences of children in countries other than Australia to reveal unique contextual factors influencing creativity.

6.6.3 Validating the process of focus

While *focus* emerged as an important creative process for the children during this study, further research is needed to explore how it may manifest in other learning environments, both online and face-to-face. Doing so would help validate the findings from this study, determining whether to what extent focus serves as a process of children's creativity.

6.6.4 Nuances of online learning

It is recommended that future research distinguishes between different learning areas or activities that are delivered online, to further understanding of what can be effectively learnt in this environment. Specifically, this would assist in moving beyond the generalised conceptions of online learning that emerged during the COVID-19 pandemic, and instead understand that online learning is nuanced and influenced by the nature of the content being taught. Addressing these considerations in future research may ultimately help to further build our understanding of how to effectively foster children's creativity in online learning environments. Doing so will assist educators adapt to an ever-changing education landscape, to continue offering opportunities for key competency skills.

6.7 RECOMMENDATIONS FOR STEM ONLINE EDUCATORS

Outlined below are recommendations for STEM online educators centred around advocacy and professional development.

6.7.1 Advocate for increased Internet reliability in the regions

It was observed during this study that the effectiveness and impact of Scitech's online delivery relied on the seamless, synchronous interaction afforded through a reliable Internet connection. This study experienced minor interruptions due to unstable connections. This experience aligns with existing understandings of the digital divide that exists in Australia and impacts on children's access to education services. The positive findings from this study demonstrate the potential for online learning to be used intentionally by education providers such as Scitech to reach regional children. As such, it is recommended that online educator providers advocate to the government and Internet provides for continuing improvements to the reliability of Internet connections across the regions.

6.7.2 Professional development

The findings from this study offer insight into strategies that online education providers can incorporate into their STEM learning experiences to help foster children's creativity. At a minimum, it is recommended that educators who deliver online STEM activities are provided with the guidelines presented in Figure 6.1 as a reference when preparing their online sessions. Further, live, or pre-recorded professional development sessions could provide more comprehensive strategies for educators to consider incorporating into their delivery. The information provided to online education providers would include not only strategies for themselves during delivery, but also information to convey to classroom teachers and caregivers who would support the children during their sessions. The dissemination of these professional development resources could be made available by the researcher to online educator providers in Australia, such as Scitech.

6.8 CONCLUDING REMARKS

STEM education is an effective way of fostering the key competency skill of creativity in young children. As Western Australia's leading science discovery centre, Scitech is uniquely placed to engage with regional and remote schools every three to five years. However, the inclusion of online delivery presents an unprecedented opportunity to strengthen these connections by offering more frequent access to STEM learning experiences. Implications from these findings extend well beyond Scitech, with the development of practical guidelines to support other STEM online educators. This in turn has far-reaching implications, particularly for children living in regional and remote areas who often lack access to quality STEM learning experiences. By transcending physical barriers, online delivery can provide meaningful learning opportunities. Further, the study contributes to international research fields by identifying several affordances of online delivery and thus challenging assumptions about its suitability for young learners. Findings demonstrate that existing pedagogies can be adapted to engage young children within online learning environments. These findings additionally contribute to our understanding of children's creativity, and how it can be demonstrated and developed in different contexts. As aptly expressed by Scitech facilitator, Milly, "I feel the sky's the limit when it comes to fostering creativity through online engagement." This study lays the foundation for a future where all children, regardless of their location, can access quality STEM education and unleash their creative potential.

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APPENDICES

Appendix 1 Curtin Ethics Approval

Curtin University

Research Office at Curtin

GPO Box U1987
Perth Western Australia 6845

Telephone +61 8 9266 7863
Facsimile +61 8 9266 3793
Web research.curtin.edu.au

29-Jun-2022

Name: Karen Murcia
Department/School: School of Education
Email: Karen.Murcia@curtin.edu.au

Dear Karen Murcia

RE: Ethics Office approval
Approval number: HRE2022-0342

Thank you for submitting your application to the Human Research Ethics Office for the project **Fostering children's creativity with STEM activities in online learning environments**.

Your application was reviewed through the Curtin University Low risk review process.

The review outcome is: **Approved**.

Your proposal meets the requirements described in the National Health and Medical Research Council's (NHMRC) *National Statement on Ethical Conduct in Human Research (2007)*.

Approval is granted for a period of one year from **29-Jun-2022** to **28-Jun-2023**. Continuation of approval will be granted on an annual basis following submission of an annual report.

Personnel authorised to work on this project:

Name	Role
Murcia, Karen	CI
Blackley, Susan	Co-Inv
Maslin, Kimberly	Student

Approved documents:

Document

Standard conditions of approval

1. Research must be conducted according to the approved proposal
2. Report in a timely manner anything that might warrant review of ethical approval of the project including:
    - proposed changes to the approved proposal or conduct of the study
    - unanticipated problems that might affect continued ethical acceptability of the project
    - major deviations from the approved proposal and/or regulatory guidelines
    - serious adverse events
3. Amendments to the proposal must be approved by the Human Research Ethics Office before they are implemented (except where an amendment is undertaken to eliminate an immediate risk to participants)
4. An annual progress report must be submitted to the Human Research Ethics Office on or before the anniversary of approval and a

completion report submitted on completion of the project

5. Personnel working on this project must be adequately qualified by education, training and experience for their role, or supervised
6. Personnel must disclose any actual or potential conflicts of interest, including any financial or other interest or affiliation, that bears on this project
7. Changes to personnel working on this project must be reported to the Human Research Ethics Office
8. Data and primary materials must be retained and stored in accordance with the Western Australian University Sector Disposal Authority (WAUSDA) and the Curtin University Research Data and Primary Materials policy
9. Where practicable, results of the research should be made available to the research participants in a timely and clear manner
10. Unless prohibited by contractual obligations, results of the research should be disseminated in a manner that will allow public scrutiny; the Human Research Ethics Office must be informed of any constraints on publication
11. Approval is dependent upon ongoing compliance of the research with the Australian Code for the Responsible Conduct of Research, the National Statement on Ethical Conduct in Human Research, applicable legal requirements, and with Curtin University policies, procedures and governance requirements
12. The Human Research Ethics Office may conduct audits on a portion of approved projects.

Special Conditions of Approval

1. Please provide a copy of the verbal script that will be used to recruit the Year 1 teachers and the SciTech facilitators.
Note: Your recruitment script should contain a short description of your project, (what is it about, who is conducting the research, is it a staff or student project, what are the benefits of taking part, what the participants have to do and how long it will take them to complete the interview/observational component), and ensure that you include the following narrative "Curtin University Human Research Ethics Committee (HREC) has approved this study (HREC number HRE2022-XXXX)."

2. It is the responsibility of the Chief Investigator to ensure that any activity undertaken under this project adheres to the latest available advice from the Government or the University regarding COVID-19.

This letter constitutes low risk/negligible risk approval only. This project may not proceed until you have met all of the Curtin University research governance requirements.

Should you have any queries regarding consideration of your project, please contact the Ethics Support Officer for your faculty or the Ethics Office at hrec@curtin.edu.au or on 9266 2784.

Yours sincerely

Amy Bowater
Ethics, Team Lead

Appendix 2 CEWA Ethics Approval

CATHOLIC EDUCATION
WESTERN AUSTRALIA
EXECUTIVE DIRECTOR OF CATHOLIC EDUCATION

12 July 2022

Ms Kimberly Maslin
Curtin University School of Education
GPO Box U1987
BENTLEY WA 6845

Email: Kimberly.maslin1@postgrad.curtin.edu.au

Dear Ms Maslin

FOSTERING CHILDREN'S CREATIVITY WITH STEM ACTIVITIES IN ONLINE LEARNING ENVIRONMENTS – CEWA REFERENCE RP2022/22

Thank you for your completed application received 30 May 2022 where your research will use a case study approach to examine how children's creativity can be fostered in STEM, in an online learning environment. I give in principle support for the selected Catholic school in Western Australia to participate in this valuable study. The research is classified as;

IMPORTANT

noting the focus on an important study area in primary schools, and the context of an online learning context.

Consistent with Catholic Education Western Australia Limited (CEWA) policy, participation in your research project will be the decision of the individual principal and staff members. A copy of this letter must be provided to the principal when requesting their participation in the research.

Approval is granted on condition that a final copy of the survey questions is to be provided to CEWA, if they differ from the current draft provided.

Responsibility for quality control of ethics and methodology of the proposed research resides with the institution supervising the research. CEWA notes that Curtin University Human Research Ethics Committee has granted permission for the duration of this research project (Reference Number: HRE2022-034).

Any changes to the proposed methodology will need to be submitted for CEWA approval prior to implementation. The focus and outcomes of your research project are of interest to CEWA. It is therefore a condition of approval that the research findings of this study are forwarded to CEWA.

Further enquiries may be directed to John Nelson at john.nelson@cewa.edu.au or (08) 6380 5313. I wish you all the best with your research.

Yours sincerely

Dr Debra Sayce
Executive Director

Catholic Education Western Australia Limited | (08) 9380 1800 | www.cewa.edu.au
50 Ruislip Street West Leederville WA 6007 | PO Box 198 Leederville WA 6903 | ABN: 47 634 504 135

Appendix 3 Principal Invitation Letter

Children's creativity during online STEM

Dear Mr [redacted]

My name is Kimberly Maslin, and I am a PhD student at Curtin University. My research project is looking at how to foster children's creativity with Scitech's STEM activities in online learning environments. Curtin University Human Research Ethics Committee (HREC) has approved this study (HRE2022-0342). Catholic Education Western Australia's Research committee has also approved this study (RP2022/22).

I am writing to formally invite your school, [redacted] to participate in this study.

This research would involve your Year 1 class engaging in various Scitech STEM activities, including a Live Science Show, Live Puppet Show and open-ended STEM activity delivered online by Scitech facilitators. These will take place in the Year 1 classroom during Term 3 and Term 4, 2022. The research will also involve focus children engaging in a 4-week after-school home-based STEM Club delivered online by Scitech facilitators.

I would work closely with the school, specifically your Year 1 teacher, to coordinate the observations of these activities. There would be no cost to the school to participate in the study or Scitech activities.

Your permission is required to confirm the school's participation in the study.

The activities in the classroom would comprise of one 45-minute STEM activity, two 30-minute online Scitech Live Shows and four 45-minute online STEM sessions. The at-home component would comprise of four 45-minute online STEM club sessions. The participating children would be invited to complete three interviews, each lasting no more than 20-minutes. The Year 1 teacher would be invited to complete one interview, lasting no more than 60-minutes.

I would like to arrange time to meet, where I can provide the Participant Information Form and Consent Form, as well as answer any questions you may have. If you are happy to discuss this project further, please let me know the most suitable time for a meeting.

Sincerely,
Kimberly Maslin

Student number: 19442044
Kimberly.maslin1@postgrad.curtin.edu.au

Appendix 4 Principal Participant Information Form

Curtin University

Children's creativity during online STEM

PARTICIPANT INFORMATION STATEMENT FOR PRINCIPALS

HREC Project Number:	HRE2022-0342
Project Title:	Fostering children's creativity with STEM activities in online learning environments
Chief Investigator:	Dr Karen Murcia, Associate Professor, School of Education
Student researcher:	Kimberly Maslin
Version Number:	3
Version Date:	26/07/2022

What is the project about?

Educational technologies offer opportunities for children to access creative STEM learning activities that otherwise may not be available to them. However, there has been little research that explores how to foster children's creativity in online learning environments. This research project aims to identify recommendations for the online delivery of Scitech STEM activities to young children living in regional Western Australia.

Who is doing the research?

The project is being conducted by Kimberly Maslin, under the supervision of Dr Karen Murcia and Dr Susan Blackley, Curtin University. The results of this research project will be used by her to obtain a Doctor of Philosophy at Curtin University and is funded by the ARC Centre of Excellence for the Digital Child. There will be no costs to you and you will not be paid for participating in this project.

Why am I being asked to take part and what will I have to do?

I would like to observe children in your school's Year 1 classroom as they engage in several STEM activities. Specifically, I would like to observe four focus children, although the remainder of the children would be included in the activities and possibly in the background of some recordings. As the activities would occur during Investigation Time, the Year 2/3 class would be invited to participate in the activities, however they will not be the focus of the project.

The first STEM activity would be delivered by the Year 1 teacher, while the remaining activities would be delivered by Scitech facilitators. The Scitech activities are part of their existing program – a Live Science Show, a Live Puppet Show, and an open-ended STEM project - and would be delivered to the class online.

I will work with the Year 1 teacher and Scitech to determine the best time for these activities to occur. Up to two video cameras will be set up to record the children participating in the activities for no more than 1 hour. During the observations, I will be present in the room but will not be directly interacting with the teacher or the children. I may also take photographs and make notes.

Following the activities, the teacher and focus children will be invited to participate in a short, semi-structured interview with me which will be audio recorded. This will take no longer than 30-minutes each, and the participants will not be personally identified.

Are there any benefits to being in the research project?

The research may allow for the development and improvement of educational programs, and build our understanding of best practice for online delivery of creative STEM activities. The Year 1 class at your school will also be able to participate in two Live Scitech Shows and one open-ended Scitech project delivered by Scitech facilitators at no cost. There may also be professional development opportunities available to your school, following the completion of the study with the findings.

Are there any risks, side-effects, discomforts or inconveniences from being in the research project?

There are no foreseeable risks from this research project. Apart from giving up your time, I do not expect that there will be any risks or inconveniences associated with taking part in this study. Any and all requirements and guidelines relating to COVID-19 (e.g. mask wearing, hand sanitisation, physical distancing) will be adhered to during the observations.

Who will have access to my information?

The information collected in this research will be re-identifiable. This means that any information I collect that can identify participants will stay on the information I collect and will be treated as confidential and used only in the project unless otherwise stated. I can let others know this information only if you say so or if the law says I need to. When the information is analysed and published, any identifying features will be removed (e.g. faces and/or school logos will be blurred). Your school will be referred to using a made-up name or code. The following people will have access to the information we collect in this research: the research team and, in the event of an audit or investigation, staff from Curtin University Office of Research and Development.

All information and electronic data will be password-protected and backed up onto Curtin University's secure electronic Research Drive. Hard copy data will be in locked storage and securely destroyed once digitised. As required by the Western Australian University Sector Disposal Authority, the information we collect in this study will be kept under secure conditions at Curtin University until children involved reach 25 years old then it will be destroyed. The results of this research, as well as de-identified still images and transcribed quotes from participants, may be presented at conferences or published in professional journals. They will also be published as part of Kimberly Maslin's PhD thesis. You will not be personally identified in any results that are published or presented.

Will you tell me the results of the research?

I will write to you at the end of this phase of the research (about 6 months after the observation) and let you know the results of the research. Results will not be individual but based on all the information we collect and review as part of the research.

Do I have to take part in the research?

Children's creativity during online STEM
Taking part in a research project is voluntary. It is your choice to take part or not. You do not have to agree if you do not want to. If you decide to take part and then change your mind, that is okay, you can withdraw from the project.

What happens next and who can I contact about the research?

To provide consent to participate in this research project, please complete the Consent Form and return to Kimberly Maslin either via email (kimberly.maslin1@postgrad.curtin.edu.au) or leave in a sealed envelope for collection at School Reception.

If you have any further questions or would like to contact the researchers, please email Kimberly Maslin kimberly.maslin1@postgrad.curtin.edu.au or the research supervisor (CI) A/Professional Karen Murcia karen.murcia@curtin.edu.au.

Curtin University Human Research Ethics Committee (HREC) has approved this study (HREC number HRE2022-0342). Should you wish to discuss the study with someone not directly involved, in particular, any matters concerning the conduct of the study or your rights as a participant, or you wish to make a confidential complaint, you may contact the Ethics Officer on (08) 9266 9223 or the Manager, Research Integrity on (08) 9266 7093 or email hrec@curtin.edu.au.

Appendix 5 Principal Consent Form

Children's creativity during online STEM

CONSENT FORM FOR PRINCIPAL

HREC Project Number:	HRE2022-0342
Project Title:	Fostering children's creativity with STEM activities in online learning environments
Chief Investigator:	Dr Karen Murcia, Associate Professor, School of Education
Student researcher:	Kimberly Maslin
Version Number:	1
Version Date:	26/05/2022

- I have read the information statement version listed above and I understand its contents.
- I believe I understand the purpose, extent and possible risks of my involvement in this project.
- I voluntarily consent for my school community to take part in this research project.
- I have had an opportunity to ask questions and I am satisfied with the answers I have received.
- I understand that this project has been approved by Curtin University Human Research Ethics Committee and will be carried out in line with the National Statement on Ethical Conduct in Human Research (2007).
- I understand I will receive a copy of this Information Statement and Consent Form.

Participant Name	
Participant Signature	
Date	

Appendix 6 Year 1 Teacher Participant Information Form

Curtin University

Children's creativity during online STEM

PARTICIPANT INFORMATION STATEMENT FOR EDUCATORS

HREC Project Number:	HRE2022-0342
Project Title:	Fostering children's creativity with STEM activities in online learning environments
Chief Investigator:	Dr Karen Murcia, Associate Professor, School of Education
Student researcher:	Kimberly Maslin
Version Number:	2
Version Date:	20/06/2022

What is the project about?

Educational technologies offer opportunities for children to access creative STEM learning activities that otherwise may not be available to them. However, there has been little research that explores how to foster children's creativity in online learning environments. This research project aims to identify recommendations for the online delivery of Scitech STEM activities to young children living in regional Western Australia.

Who is doing the research?

The project is being conducted by Kimberly Maslin, under the supervision of Dr Karen Murcia and Dr Susan Blackley, Curtin University. The results of this research project will be used by her to obtain a Doctor of Philosophy at Curtin University and is funded by the ARC Centre of Excellence for the Digital Child. There will be no costs to you and you will not be paid for participating in this project.

Why am I being asked to take part and what will I have to do?

I would like to observe children in your classroom as they engage in several STEM activities. Specifically, I would like to observe four focus children, although the remainder of the children would included in the activities and possibly in the background of some recordings.

The first STEM activity would be delivered by yourself, while the remaining activities would be delivered by Scitech facilitators. The Scitech activities are part of their existing program – a Live Science Show, a Live Puppet Show, and an open-ended STEM project - and would be delivered to your class online.

I will work with yourself and Scitech to determine the best time for these activities to occur. Up to two video cameras will be set up to record the children participating in the activities for no more than 1 hour. During the observations, I will be present in the room but will not be directly interacting with yourself or the children. I may also take photographs and make notes.

Following the activities, you will be invited to participate in a short, semi-structured interview with me which will be audio recorded. This will take no longer than 30-minutes and you will not be personally identified.

Are there any benefits to being in the research project?

The research may allow for the development and improvement of educational programs, and build our understanding of best practice for online delivery of creative STEM activities. Your class will also be able to participate in two Live Scitech Shows and one open-ended Scitech project delivered by Scitech facilitators at no cost. There may also be professional development opportunities available to yourself and your school, following the completion of the study with the findings.

Are there any risks, side-effects, discomforts or inconveniences from being in the research project?

There are no foreseeable risks from this research project. Apart from you giving up your time, I do not expect that there will be any risks or inconveniences associated with taking part in this study. Any and all requirements and guidelines relating to COVID-19 (e.g. mask wearing, hand sanitisation, physical distancing) will be adhered to during the observations.

Who will have access to my information?

The information collected in this research will be re-identifiable. This means that any information I collect that can identify you will stay on the information I collect and will be treated as confidential and used only in the project unless otherwise stated. I can let others know this information only if you say so or if the law says I need to. When the information is analysed and published, any identifying features will be removed (e.g. faces and/or school logos will be blurred). You and your school will be referred to using a made-up name or code. The following people will have access to the information we collect in this research: the research team and, in the event of an audit or investigation, staff from Curtin University Office of Research and Development.

All information and electronic data will be password-protected and backed up onto Curtin University's secure electronic Research Drive. Hard copy data will be in locked storage and securely destroyed once digitised. As required by the Western Australian University Sector Disposal Authority, the information we collect in this study will be kept under secure conditions at Curtin University until children involved reach 25 years old then it will be destroyed. The results of this research, as well as de-identified still images and transcribed quotes from participants, may be presented at conferences or published in professional journals. They will also be published as part of Kimberly Maslin's PhD thesis. You will not be personally identified in any results that are published or presented.

Will you tell me the results of the research?

I will write to you at the end of this phase of the research (about 6 months after the observation) and let you know the results of the research. Results will not be individual but based on all the information we collect and review as part of the research.

Do I have to take part in the research?

Taking part in a research project is voluntary. It is your choice to take part or not. You do not have to agree if you do not want to. If you decide to take part and then change your mind, that is okay, you can withdraw from the project. If you choose not to take part or start and then stop the study, it will not affect your relationship with your employer or the university. If you choose to leave the study I will use any information collected unless you tell us not to.

<u>What happens next and who can I contact about the research?</u>

To provide consent to participate in this research project, please complete the Consent Form and return to Kimberly Maslin either via email (kimberly.maslin1@postgrad.curtin.edu.au) or leave in a sealed envelope for collection at School Reception.

If you have any further questions or would like to contact the researchers, please email Kimberly Maslin kimberly.maslin1@postgrad.curtin.edu.au or the research supervisor (CI) A/Professional Karen Murcia karen.murcia@curtin.edu.au.

Curtin University Human Research Ethics Committee (HREC) has approved this study (HREC number HRE2022-0342). Should you wish to discuss the study with someone not directly involved, in particular, any matters concerning the conduct of the study or your rights as a participant, or you wish to make a confidential complaint, you may contact the Ethics Officer on (08) 9266 9223 or the Manager, Research Integrity on (08) 9266 7093 or email hrec@curtin.edu.au.

Appendix 7 Year 1 Teacher Consent Form

Children's creativity during online STEM

CONSENT FORM FOR EDUCATORS

HREC Project Number:	HRE2022-0342
Project Title:	Fostering children's creativity with STEM activities in online learning environments
Chief Investigator:	Dr Karen Murcia, Associate Professor, School of Education
Student researcher:	Kimberly Maslin
Version Number:	1
Version Date:	26/05/2022

- I have read the information statement version listed above and I understand its contents.
- I believe I understand the purpose, extent and possible risks of my involvement in this project.
- I voluntarily consent to take part in this research project.
- I consent to being audio and video recorded for the purposes of this research.
- I have had an opportunity to ask questions and I am satisfied with the answers I have received.
- I understand that this project has been approved by Curtin University Human Research Ethics Committee and will be carried out in line with the National Statement on Ethical Conduct in Human Research (2007).
- I understand I will receive a copy of this Information Statement and Consent Form.

Participant Name	
Participant Signature	
Date	

Appendix 8 Year 2/3 Teacher Participant Information Form

Curtin University

Children's creativity during online STEM

PARTICIPANT INFORMATION STATEMENT FOR EDUCATORS (YEAR 2/3)

HREC Project Number:	HRE2022-0342
Project Title:	Fostering children's creativity with STEM activities in online learning environments
Chief Investigator:	Dr Karen Murcia, Associate Professor, School of Education
Student researcher:	Kimberly Maslin
Version Number:	1
Version Date:	22/07/2022

What is the project about?

Educational technologies offer opportunities for children to access creative STEM learning activities that otherwise may not be available to them. However, there has been little research that explores how to foster children's creativity in online learning environments. This research project aims to identify recommendations for the online delivery of Scitech STEM activities to young children living in regional Western Australia.

Who is doing the research?

The project is being conducted by Kimberly Maslin, under the supervision of Dr Karen Murcia and Dr Susan Blackley, Curtin University. The results of this research project will be used by her to obtain a Doctor of Philosophy at Curtin University and is funded by the ARC Centre of Excellence for the Digital Child. There will be no costs to you and you will not be paid for participating in this project.

Why am I being asked to take part and what will I have to do?

I would like to observe children in your classroom as they engage in several STEM activities. One of these activities would be delivered by the Year 1 classroom teacher, while the remaining activities would be delivered by Scitech facilitators. The Scitech activities are part of their existing program – a Live Science Show, a Live Puppet Show, and an open-ended STEM project - and would be delivered to your class online.

With your input, I will work with the Year 1 classroom teacher and Scitech to determine the best time for these activities to occur. Up to two video cameras will be set up to record the children participating in the activities for no more than 1 hour. During the observations, I will be present in the room but will not be directly interacting with yourself or the children. I may also take photographs and make notes.

Are there any benefits to being in the research project?

The research may allow for the development and improvement of educational programs, and build our understanding of best practice for online delivery of creative STEM activities. Your class will also be able to participate in two Live Scitech Shows and one open-ended Scitech project delivered by Scitech facilitators at no cost. There may also be professional development opportunities available to yourself and your school, following the completion of the study with the findings.

Are there any risks, side-effects, discomforts or inconveniences from being in the research project?

There are no foreseeable risks from this research project. Any and all requirements and guidelines relating to COVID-19 (e.g. mask wearing, hand sanitisation, physical distancing) will be adhered to during the observations.

Who will have access to my information?

The information collected in this research will be re-identifiable. This means that any information I collect that can identify you will stay on the information I collect and will be treated as confidential and used only in the project unless otherwise stated. I can let others know this information only if you say so or if the law says I need to. When the information is analysed and published, any identifying features will be removed (e.g. faces and/or school logos will be blurred). Your school will be referred to using a made-up name or code. The following people will have access to the information we collect in this research: the research team and, in the event of an audit or investigation, staff from Curtin University Office of Research and Development.

All information and electronic data will be password-protected and backed up onto Curtin University's secure electronic Research Drive. Hard copy data will be in locked storage and securely destroyed once digitised. As required by the Western Australian University Sector Disposal Authority, the information we collect in this study will be kept under secure conditions at Curtin University until children involved reach 25 years old then it will be destroyed. The results of this research, as well as de-identified still images may be presented at conferences or published in professional journals. They will also be published as part of Kimberly Maslin's PhD thesis. You will not be personally identified in any results that are published or presented.

Do I have to take part in the research?

Taking part in a research project is voluntary. It is your choice to take part or not. You do not have to agree if you do not want to. If you decide to take part and then change your mind, that is okay, you can withdraw from the project. If you choose not to take part or start and then stop the study, it will not affect your relationship with your employer or the university. If you choose to leave the study I will use any information collected unless you tell us not to.

What happens next and who can I contact about the research?

To provide consent to participate in this research project, please complete the Consent Form and return to Kimberly Maslin either via email (kimberly.maslin1@postgrad.curtin.edu.au) or leave in a sealed envelope for collection at School Reception.

Children's creativity during online STEM

If you have any further questions or would like to contact the researchers, please email Kimberly Maslin kimberly.maslin1@postgrad.curtin.edu.au or the research supervisor (CI) A/Professional Karen Murcia karen.murcia@curtin.edu.au.

Curtin University Human Research Ethics Committee (HREC) has approved this study (HREC number HRE2022-0342). Should you wish to discuss the study with someone not directly involved, in particular, any matters concerning the conduct of the study or your rights as a participant, or you wish to make a confidential complaint, you may contact the Ethics Officer on (08) 9266 9223 or the Manager, Research Integrity on (08) 9266 7093 or email hrec@curtin.edu.au.

Appendix 9 Year 2/3 Teacher Consent Form

Children's creativity during online STEM

CONSENT FORM FOR EDUCATORS (YEAR 2/3)

HREC Project Number:	HRE2022-0342
Project Title:	Fostering children's creativity with STEM activities in online learning environments
Chief Investigator:	Dr Karen Murcia, Associate Professor, School of Education
Student researcher:	Kimberly Maslin
Version Number:	1
Version Date:	22/07/2022

- I have read the information statement version listed above and I understand its contents.
- I believe I understand the purpose, extent and possible risks of my involvement in this project.
- I voluntarily consent to take part in this research project.
- I consent to being audio and video recorded for the purposes of this research.
- I have had an opportunity to ask questions and I am satisfied with the answers I have received.
- I understand that this project has been approved by Curtin University Human Research Ethics Committee and will be carried out in line with the National Statement on Ethical Conduct in Human Research (2007).
- I understand I will receive a copy of this Information Statement and Consent Form.

Participant Name	
Participant Signature	
Date	

Appendix 10 Year 1 Family Invitation Letter

Curtin University

Children's creativity during online STEM

Dear families,

My name is Kimberly Maslin, and I am a PhD student at Curtin University. My research project is looking at how to foster children's creativity with Scitech's STEM activities in online learning environments. Curtin University Human Research Ethics Committee (HREC) has approved this study (HRE2022-0342). Catholic Education Western Australia's Research committee has also approved this study.
Your Principal, Mr Luke Shaw has very kindly allowed me to work with your school on this project.

This research involves the Year 1 class engaging in various Scitech STEM activities, including a face-to-face STEM activity (45-minutes), a Live Science Show (30-minutes), Live Puppet Show (30-minutes) and open-ended STEM activity delivered online by Scitech facilitators (four 45-minute sessions). These will take place in the Year 1 classroom during Term 3 and Term 4, 2022. The research will also involve 'focus' children engaging in a 4-week at-home, after school STEM Club, delivered online by Scitech facilitators during Term 4, 2022. Each session of the at-home STEM Club would last 45-minutes.

The participating children would be invited to complete three interviews, each lasting no more than 20-minutes. The Year 1 teacher would be invited to complete one interview, lasting no more than 60-minutes.

Invitation: 'Focus' child participants
I am seeking children from the Year 1 classroom to participate as 'focus' children in this study. These children would participate in all classroom activities as well as the at-home, after school STEM Club. I would video record these children both in the classroom, and in your home during one of the STEM Club sessions. I would also conduct an audit of the digital technologies in your home, to better understand how they are used to foster creativity. You and your child will be invited to complete a short interview with me after the activities. This interview would last no more than 40-minutes. You child would also be invited to participate in three interviews during school time, each lasting no more than 20-minutes.

Incidental Recordings
All children in the Year 1 classroom who are not a 'focus' child will be regarded as 'incidental' children for the purposes of this project unless you nominate to opt them out of the study. As an 'incidental' child, they will not be the focus of the project but may be video captured in the background of classroom activities. They will not participate in the after-school STEM club or interviews.

Next Steps
Please read through the attached Participant Information Form for further information about this project. If you wish to nominate your child as a 'focus' child, or to opt-out from the project, please complete and return the Consent Form. You are invited to reach out if you have any questions.

I know your time is precious and I very much appreciate your consideration of my request and support of this project. Your participation really helps to build our understanding of using educational technologies to support the learning of children living in remote and regional areas.

Sincerely,

Kimberly Maslin

Student number: 19442044
Kimberly.maslin1@postgrad.curtin.edu.au

Appendix 11 Year 1 Family Participant Information Form

Curtin University

Children's creativity during online STEM

PARTICIPANT INFORMATION STATEMENT FOR CAREGIVERS (YEAR 1)

HREC Project Number:	HRE2022-0342
Project Title:	Fostering children's creativity with STEM activities in online learning environments
Chief Investigator:	Dr Karen Murcia, Associate Professor, School of Education
Student researcher:	Kimberly Maslin
Version Number:	2
Version Date:	20/06/2022

What is the project about?

Educational technologies offer opportunities for children to access creative STEM learning activities that otherwise may not be available to them. However, there has been little research that explores how to foster children's creativity in online learning environments. This research project aims to identify recommendations for the online delivery of Scitech STEM activities to young children living in regional Western Australia.

Who is doing the research?

The project is being conducted by Kimberly Maslin, under the supervision of Dr Karen Murcia and Dr Susan Blackley, Curtin University. The results of this research project will be used by her to obtain a Doctor of Philosophy at Curtin University and is funded by the ARC Centre of Excellence for the Digital Child. There will be no costs to you and you will not be paid for participating in this project.

Why am I being asked to take part and what will I have to do?

Focus Families

I am looking for volunteers who care for a child in Year 1. This is because I am seeking to understand how children of this age engage in creative STEM activities in online environments.

Your participation would firstly involve giving permission for me to observe and video record your child as they participate in several Scitech STEM activities in their classroom, as well as audio-record three interviews with them that would last no more than 20 minutes. These would be conducted during school time in Term 3 and Term 4, 2022. The classroom sessions would involve one 45-minute face-to-face STEM activity, two 30-minute online Live Scitech Shows and four 45-minute online Scitech STEM workshops.

Your participation would secondly involve giving permission for your child to participate in a four-week after school, online STEM Club delivered by Scitech. Each session would last 45-minutes. I would conduct a home visit prior to this session to introduce myself and would observe and video record one of the sessions in your house. Your child would also be recorded via screen recording during the delivery of all four online sessions. Following the completion of the four STEM club sessions, you and your child would be invited to participate in an audio-recorded interview that would last no more than 30 minutes. This would be conducted after school in Term 4, 2022.

Incidental Families

Families who do not volunteer as 'focus' families will still participate in all classroom Scitech activities during Term 4. However, they will not be interviewed, and they will not participate in the after school STEM club.

Children not participating as 'focus' children may be video captured in the background during these activities. However, they are not the focus of the project and they will not be identifiable in any dissemination of the research.

Are there any benefits to being in the research project?

The research may allow for the development and improvement of online STEM learning programs and build our understanding of how we can engage children in remote and regional areas with creative STEM activities. Further, your child will have the opportunity to participate in two Live Scitech Shows and one open-ended Scitech project at school, and a four-week Scitech delivered STEM Club at home at no cost.

Are there any risks, side-effects, discomforts or inconveniences from being in the research project?

There are no foreseeable risks from this research project. Apart from you giving up your time, I do not expect that there will be any risks or inconveniences associated with taking part in this study. Any and all requirements and guidelines relating to COVID-19 (e.g. mask wearing, hand sanitisation, physical distancing) will be adhered to during the observations.

Who will have access to my information?

The information collected in this research will be re-identifiable. This means that any information I collect that can identify you will stay on the information I collect and will be treated as confidential and used only in the project unless otherwise stated. I can let others know this information only if you say so or if the law says I need to. When the information is analysed and published, any identifying features will be removed. You and your child will be referred to using a made-up name or code. The following people will have access to the information we collect in this research: the research team and, in the event of an audit or investigation, staff from Curtin University Office of Research and Development.

All information and electronic data will be password-protected and backed up onto Curtin University's secure electronic Research Drive. Hard copy data will be in locked storage and securely destroyed once digitised. As required by the Western Australian University Sector Disposal Authority, the information we collect in this study will be kept under secure conditions at Curtin University until children involved reach 25 years old then it will be destroyed. The results of this research, as well as de-identified still images and transcribed quotes from participants, may be presented at conferences or published in professional journals. They will also be published as part of Kimberly Maslin's PhD thesis. You will not be personally identified in any results that are published or presented.

Curtin University

Children's creativity during online STEM

PARTICIPANT INFORMATION STATEMENT FOR CAREGIVERS (YEAR 1)

HREC Project Number:	HRE2022-0342
Project Title:	Fostering children's creativity with STEM activities in online learning environments
Chief Investigator:	Dr Karen Murcia, Associate Professor, School of Education
Student researcher:	Kimberly Maslin
Version Number:	2
Version Date:	20/06/2022

What is the project about?

Educational technologies offer opportunities for children to access creative STEM learning activities that otherwise may not be available to them. However, there has been little research that explores how to foster children's creativity in online learning environments. This research project aims to identify recommendations for the online delivery of Scitech STEM activities to young children living in regional Western Australia.

Who is doing the research?

The project is being conducted by Kimberly Maslin, under the supervision of Dr Karen Murcia and Dr Susan Blackley, Curtin University. The results of this research project will be used by her to obtain a Doctor of Philosophy at Curtin University and is funded by the ARC Centre of Excellence for the Digital Child. There will be no costs to you and you will not be paid for participating in this project.

Why am I being asked to take part and what will I have to do?

Focus Families

I am looking for volunteers who care for a child in Year 1. This is because I am seeking to understand how children of this age engage in creative STEM activities in online environments.

Your participation would firstly involve giving permission for me to observe and video record your child as they participate in several Scitech STEM activities in their classroom, as well as audio-record three interviews with them that would last no more than 20 minutes. These would be conducted during school time in Term 3 and Term 4, 2022. The classroom sessions would involve one 45-minute face-to-face STEM activity, two 30-minute online Live Scitech Shows and four 45-minute online Scitech STEM workshops.

Your participation would secondly involve giving permission for your child to participate in a four-week after school, online STEM Club delivered by Scitech. Each session would last 45-minutes. I would conduct a home visit prior to this session to introduce myself and would observe and video record one of the sessions in your house. Your child would also be recorded via screen recording during the delivery of all four online sessions. Following the completion of the four STEM club sessions, you and your child would be invited to participate in an audio-recorded interview that would last no more than 30 minutes. This would be conducted after school in Term 4, 2022.

Incidental Families

Families who do not volunteer as 'focus' families will still participate in all classroom Scitech activities during Term 4. However, they will not be interviewed, and they will not participate in the after school STEM club.

Children not participating as 'focus' children may be video captured in the background during these activities. However, they are not the focus of the project and they will not be identifiable in any dissemination of the research.

Are there any benefits to being in the research project?

The research may allow for the development and improvement of online STEM learning programs and build our understanding of how we can engage children in remote and regional areas with creative STEM activities. Further, your child will have the opportunity to participate in two Live Scitech Shows and one open-ended Scitech project at school, and a four-week Scitech delivered STEM Club at home at no cost.

Are there any risks, side-effects, discomforts or inconveniences from being in the research project?

There are no foreseeable risks from this research project. Apart from you giving up your time, I do not expect that there will be any risks or inconveniences associated with taking part in this study. Any and all requirements and guidelines relating to COVID-19 (e.g. mask wearing, hand sanitisation, physical distancing) will be adhered to during the observations.

Who will have access to my information?

The information collected in this research will be re-identifiable. This means that any information I collect that can identify you will stay on the information I collect and will be treated as confidential and used only in the project unless otherwise stated. I can let others know this information only if you say so or if the law says I need to. When the information is analysed and published, any identifying features will be removed. You and your child will be referred to using a made-up name or code. The following people will have access to the information we collect in this research: the research team and, in the event of an audit or investigation, staff from Curtin University Office of Research and Development.

All information and electronic data will be password-protected and backed up onto Curtin University's secure electronic Research Drive. Hard copy data will be in locked storage and securely destroyed once digitised. As required by the Western Australian University Sector Disposal Authority, the information we collect in this study will be kept under secure conditions at Curtin University until children involved reach 25 years old then it will be destroyed. The results of this research, as well as de-identified still images and transcribed quotes from participants, may be presented at conferences or published in professional journals. They will also be published as part of Kimberly Maslin's PhD thesis. You will not be personally identified in any results that are published or presented.

Will you tell me the results of the research?

I will write to you at the end of this phase of the research (about 6 months after the observation) and let you know the results of the research. Results will not be individual but based on all the information we collect and review as part of the research.

Do I have to take part in the research?

Taking part in a research project is voluntary. It is your choice to take part or not. You do not have to agree if you do not want to. If you decide to take part and then change your mind, that is okay, you can withdraw from the project. If you choose not to take part or start and then stop the study, it will not affect your or the child's relationship with their education provider. If you choose to leave the study I will use any information collected unless you tell us not to.

What happens next and who can I contact about the research?

To provide consent for you and your child to participate in this research project, please complete the Consent Form and return to [Year 1 Teacher] in a sealed envelope.

If you have any further questions or would like to contact the researchers, please email Kimberly Maslin kimberly.maslin1@postgrad.curtin.edu.au or the research supervisor (CI) A/Professional Karen Murcia karen.murcia@curtin.edu.au.

Curtin University Human Research Ethics Committee (HREC) has approved this study (HREC number HRE2022-0342). Should you wish to discuss the study with someone not directly involved, in particular, any matters concerning the conduct of the study or your rights as a participant, or you wish to make a confidential complaint, you may contact the Ethics Officer on (08) 9266 9223 or the Manager, Research Integrity on (08) 9266 7093 or email hrec@curtin.edu.au.

Appendix 12 Year 1 Family Consent Form

Curtin University

Children's creativity during online STEM

CONSENT FORM FOR CAREGIVER & CHILD (YEAR 1)

HREC Project Number:	HRE2022-0342
Project Title:	Fostering children's creativity with STEM activities in online learning environments
Chief Investigator:	Dr Karen Murcia, Associate Professor, School of Education
Student researcher:	Kimberly Maslin
Version Number:	2
Version Date:	26/05/2022

All children in the Year 1 classroom will be regarded as 'incidental' children for the purposes of this project, unless otherwise nominated below. As an 'incidental' child, your child will not be the focus of the project but may be video captured in the background of classroom activities. If this form is not returned, your consent for your child to participate as an 'incidental' child will be assumed.
If you wish to nominate your child as a 'focus' child, or to opt-out from this project, please tick one of the following boxes:

☐ **'Focus' Child**

- I understand that my child will be audio/video recorded during this observation.
- I understand that I may be videoed while engaging with my child during the home observation.
- I understand that mine and my child's interviews will be audio-recorded.

☐ **Opt-Out**

- I do not wish for my child to participate in this study.
- I understand my child will not participate in the Scitech STEM activities delivered in to their class

For all families:

- I have read the information statement version listed above and I understand its contents.
- I believe I understand the purpose, extent and possible risks of my involvement in this project.
- I understand that my child will be regarded as an 'incidental' child unless I have stated otherwise.
- I voluntarily consent to take part in this research project.
- I have had an opportunity to ask questions and I am satisfied with the answers I have received.
- I understand that this project has been approved by Curtin University Human Research Ethics Committee and will be carried out in line with the National Statement on Ethical Conduct in Human Research (2007).
- I understand I will receive a copy of this Information Statement and Consent Form.

Participant Name	
Participant Signature	
Date	

Participant Consent Form – Caregiver & Child - Version 2, 24 JUNE 2022 *Page 1*

CRICOS Provider Code 00301J

CHILD (Please help the child in your care with this section)

Note this only needs to be completed if you are nominating as a ‘focus’ child

- I understand that someone will be recording and taking photographs of me
- I understand that they might write some things down about what I’m doing.
- I understand that I can tell them to stop if I don’t want them to do that anymore, and they won’t be upset.

Please colour in the thumbs-up and write your name underneath to tell me that this is okay.

Appendix 13 Year 2/3 Family Invitation Letter

Curtin University

Children's creativity during online STEM

Dear Year 2/3 families,

My name is Kimberly Maslin, and I am a PhD student at Curtin University. My research project is looking at how to foster children's creativity with Scitech's STEM activities in online learning environments. Curtin University Human Research Ethics Committee (HREC) has approved this study (HRE2022-0342). Catholic Education Western Australia's Research committee has also approved this study.
Your Principal, Mr Luke Shaw has very kindly allowed me to work with your school on this project.

This research involves the children engaging in various Scitech STEM activities, including a face-to-face STEM activity (45-minutes), a Live Science Show (30-minutes), Live Puppet Show (30-minutes) and open-ended STEM activity delivered online by Scitech facilitators (four 45-minute sessions).

The 'focus' children for this study will be selected from Year 1. However, as the activities will be taking place during afternoon Investigation Time (a joint learning time for the Year 1 and Year 2/3 classes), your child will have the opportunity to participate in the activities as well.

Incidental Recordings
All children in the Year 2/3 classroom will be regarded as 'incidental' children for the purposes of this project unless you nominate to opt them out of the study. As an 'incidental' child, they will not be the focus of the project but may be video captured in the background of classroom activities.

Next Steps
Please read through the attached Participant Information Form for further information about this project. If you wish to opt-out from the project, please complete and return the Consent Form. You are invited to reach out if you have any questions.

I know your time is precious and I very much appreciate your consideration of my request and support of this project. Your participation really helps to build our understanding of using educational technologies to support the learning of children living in remote and regional areas.

Sincerely,

Kimberly Maslin

Student number: 19442044
Kimberly.maslin1@postgrad.curtin.edu.au

Appendix 14 Year 2/3 Family Participant Information Form

Curtin University

Children's creativity during online STEM

PARTICIPANT INFORMATION STATEMENT FOR CAREGIVERS (YEAR 2/3)

HREC Project Number:	HRE2022-0342
Project Title:	Fostering children's creativity with STEM activities in online learning environments
Chief Investigator:	Dr Karen Murcia, Associate Professor, School of Education
Student researcher:	Kimberly Maslin
Version Number:	1
Version Date:	22/07/2022

What is the project about?

Educational technologies offer opportunities for children to access creative STEM learning activities that otherwise may not be available to them. However, there has been little research that explores how to foster children's creativity in online learning environments. This research project aims to identify recommendations for the online delivery of Scitech STEM activities to young children living in regional Western Australia.

Who is doing the research?

The project is being conducted by Kimberly Maslin, under the supervision of Dr Karen Murcia and Dr Susan Blackley, Curtin University. The results of this research project will be used by her to obtain a Doctor of Philosophy at Curtin University and is funded by the ARC Centre of Excellence for the Digital Child. There will be no costs to you and you will not be paid for participating in this project.

Why am I being asked to take part and what will I have to do?

Incidental Families

The 'focus' children for this study will be selected from Year 1. However, as the activities will be taking place during afternoon Investigation Time (a joint learning time for the Year 1 and Year 2/3 classes), your child will have the opportunity to participate in the activities as well.

They are not the focus of the project and they will not be identifiable in any dissemination of the research.

Are there any benefits to being in the research project?

The research may allow for the development and improvement of online STEM learning programs and build our understanding of how we can engage children in remote and regional areas with creative STEM activities. Further, your child will have the opportunity to participate in two Live Scitech Shows and one open-ended Scitech project at school.

Are there any risks, side-effects, discomforts or inconveniences from being in the research project?

There are no foreseeable risks from this research project. Any and all requirements and guidelines relating to COVID-19 (e.g. mask wearing, hand sanitisation, physical distancing) will be adhered to during the observations.

Who will have access to my information?

No individual information about your child will be collected, although they may appear in the background of recordings. Where this occurs, they will not be identifiable in any dissemination of the research.

All information and electronic data will be password-protected and backed up onto Curtin University's secure electronic Research Drive. Hard copy data will be in locked storage and securely destroyed once digitised. As required by the Western Australian University Sector Disposal Authority, the information we collect in this study will be kept under secure conditions at Curtin University until children involved reach 25 years old then it will be destroyed. The results of this research, as well as de-identified still images may be presented at conferences or published in professional journals. They will also be published as part of Kimberly Maslin's PhD thesis. You will not be personally identified in any results that are published or presented.

Do I have to take part in the research?

Taking part in a research project is voluntary. It is your choice to take part or not. You do not have to agree if you do not want to. If you decide to take part and then change your mind, that is okay, you can withdraw from the project. If you choose not to take part or start and then stop the study, it will not affect your or the child's relationship with their education provider. If you choose to leave the study I will use any information collected unless you tell us not to.

What happens next and who can I contact about the research?

All children in the Year 2/3 classroom will be regarded as 'incidental' children for the purposes of this project, unless you opt-out. If the Consent Form is not returned, your consent for your child to participate as an 'incidental' child will be assumed. If you wish to opt-out from this project, please complete the Consent Form and return it to [Year 2/3 Teacher] in a sealed envelope.

If you have any further questions or would like to contact the researchers, please email Kimberly Maslin kimberly.maslin1@postgrad.curtin.edu.au or the research supervisor (CI) A/Professional Karen Murcia karen.murcia@curtin.edu.au.

Curtin University Human Research Ethics Committee (HREC) has approved this study (HREC number HRE2022-0342). Should you wish to discuss the study with someone not directly involved, in particular, any matters concerning the conduct of the study or your rights as a participant, or you wish to make a confidential complaint, you may contact the Ethics Officer on (08) 9266 9223 or the Manager, Research Integrity on (08) 9266 7093 or email hrec@curtin.edu.au.

Appendix 15 Year 2/3 Family Consent From

Curtin University

Children's creativity during online STEM

CONSENT FORM FOR CAREGIVER & CHILD (YEAR 2/3 CLASS)

HREC Project Number:	HRE2022-0342
Project Title:	Fostering children's creativity with STEM activities in online learning environments
Chief Investigator:	Dr Karen Murcia, Associate Professor, School of Education
Student researcher:	Kimberly Maslin
Version Number:	1
Version Date:	22/7/2022

All children in the Year 2/3 classroom will be regarded as 'incidental' children for the purposes of this project, unless you opt-out. As an 'incidental' child, your child will not be the focus of the project but may be video captured in the background of classroom activities. If this form is not returned, your consent for your child to participate as an 'incidental' child will be assumed.

If you wish to opt-out from this project, please tick the box below and return this form to your classroom teacher:

☐ **Opt-Out**

- I do not wish for my child to participate in this study.
- I understand my child will not participate in the Scitech STEM activities delivered to their class

For all families:
- I have read the information statement version listed above and I understand its contents.
- I believe I understand the purpose, extent and possible risks of my involvement in this project.
- I understand that my child will be regarded as an 'incidental' child unless I have stated otherwise.
- I have had an opportunity to ask questions and I am satisfied with the answers I have received.
- I understand that this project has been approved by Curtin University Human Research Ethics Committee and will be carried out in line with the National Statement on Ethical Conduct in Human Research (2007).
- I understand I will receive a copy of this Information Statement and Consent Form.

Participant Name	
Participant Signature	
Date	

Appendix 16 Classroom Meet-and-Greet PowerPoint

Hi! I'm Kim Maslin

I am a researcher from Curtin University. I also live in Esperance.

I would like to find out the ways you are creative when participating in Scitech activities.

AUSTRALIAN RESEARCH COUNCIL Centre of Excellence for the Digital Child.

Over the next few weeks, you are going to participate in some Scitech activities during Investigation time!

- 1 Live Science Show
- 4 Scitech workshops
- 1 Live Puppet Show

AUSTRALIAN RESEARCH COUNCIL Centre of Excellence for the Digital Child.

These activities are going to be run live online –

This means the Scitech presenters will be on your big TV!

AUSTRALIAN RESEARCH COUNCIL Centre of Excellence for the Digital Child.

I will be coming to watch you 7 times!

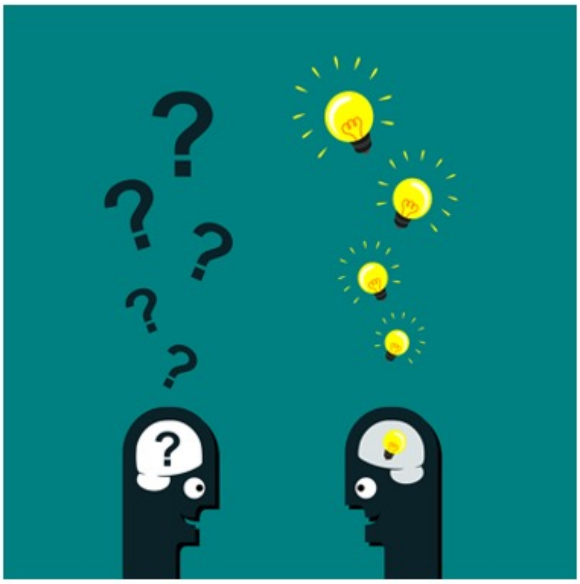
- 6 times with Scitech
- 1 time with Miss Cowie

During each of these visits, I will take some photos and videos of you.

AUSTRALIAN RESEARCH COUNCIL Centre of Excellence for the Digital Child.

I want to see:

- How you enjoy the Scitech activities online
- The ways you are creative
- The questions you ask
- The ideas you have
- The creative things you make



Just remember…

When the cameras are on, I (the researcher) can see you!

There is no 'right' or 'wrong' way to be creative – just enjoy the Scitech activities and be yourself

If you have any questions, you can ask me.

I can't wait to do this research with you! ☺

AUSTRALIAN RESEARCH COUNCIL Centre of Excellence for the Digital Child.

Appendix 17 Home Meet-and-Greet PDF

Creativity and Scitech

For families to read together

AUSTRALIAN RESEARCH COUNCIL Centre of Excellence for the Digital Child.

Curtin University

Hi! I'm Kim Maslin

I am a researcher from Curtin University. I also live in Esperance.

I would like to find out the ways you are creative when participating in Scitech activities.

AUSTRALIAN RESEARCH COUNCIL Centre of Excellence for the Digital Child.

Over the next few weeks, you are going to participate in an after school Scitech STEM Club!

Dates:

- Wednesday 26th October (Week 3)
- Wednesday 2nd November (Week 4)
- Wednesday 9th November (Week 5)
- Wednesday 16th November (Week 6)

AUSTRALIAN RESEARCH COUNCIL
Centre of Excellence for the Digital Child.

The Scitech STEM Club will be run live online –

This means the Scitech presenter will be talking to you through your device (iPad, laptop, computer).

A link to join the sessions will be emailed to your parents.

AUSTRALIAN RESEARCH COUNCIL
Centre of Excellence for the Digital Child.

I will be coming to watch you at home one time during the Scitech STEM Club.

During this visit I will take some photos and videos of you.

I will also be recording the Scitech STEM club on my computer. This means I am recording both you, the other children and the Scitech facilitator.

Later, I will come back to have a chat with you and your caregiver.

AUSTRALIAN RESEARCH COUNCIL
Centre of Excellence for the Digital Child.

I am recording you so that I can see:

- How you enjoy the Scitech activities
- The questions you ask
- The ideas you have
- The creative things you make

There is no 'right' or 'wrong' way to be creative – just enjoy the Scitech activities and be yourself ☺

AUSTRALIAN RESEARCH COUNCIL
Centre of Excellence for the Digital Child.

Just remember…

When the camera is on, I (the researcher) can see you!

You can also tell me if you would like to pause or stop.

If you have any questions, you can ask me.

I can't wait to do this research with you! ☺

Caregivers, you can contact me on

kimberly.maslin1@postgrad.curtin.edu.au

or 0410 597 699

AUSTRALIAN RESEARCH COUNCIL
Centre of Excellence for the Digital Child.

Appendix 18 Scitech Participant Information Form

Curtin University

Children's creativity during online STEM

PARTICIPANT INFORMATION STATEMENT FOR SCITECH

HREC Project Number:	HRE2022-0342
Project Title:	Fostering children's creativity with STEM activities in online learning environments
Chief Investigator:	Dr Karen Murcia, Associate Professor, School of Education
Student researcher:	Kimberly Maslin
Version Number:	2
Version Date:	20/06/2022

What is the project about?

Educational technologies offer opportunities for children to access creative STEM learning activities that otherwise may not be available to them. However, there has been little research that explores how to foster children's creativity in online learning environments. This research project aims to identify recommendations for the online delivery of Scitech STEM activities to young children living in regional Western Australia.

Who is doing the research?

The project is being conducted by Kimberly Maslin, under the supervision of Dr Karen Murcia and Dr Susan Blackley, Curtin University. The results of this research project will be used by her to obtain a Doctor of Philosophy at Curtin University and is funded by the ARC Centre of Excellence for the Digital Child. There will be no costs to you and you will not be paid for participating in this project.

Why am I being asked to take part and what will I have to do?

I would like to observe children in a regional Year 1 classroom as they engage in several Scitech STEM activities. Each of these activities would be delivered by Scitech facilitators, yourself included. The Scitech activities will be part of your existing program – namely, a Live Science Show, a Live Puppet Show, and an open-ended STEM project. You would deliver online to the children from Scitech's premises.

I will work with Scitech and the school to determine the best time for these activities to occur. Up to two video cameras will be set up to record the children participating in the activities for no more than 1 hour. You will be recorded both through screen recordings and video recordings from the classroom and home environments (where you would be projected on a screen).

During the observations, I will be present in the room with the children, but will not be directly interacting with yourself or the children. I may also take photographs and make notes.

Following the activities, you will be invited to participate in a short, semi-structured interview with me which will be audio recorded. This may take place in person or via video conferencing. This will take no longer than 30-minutes and you will not be personally identified.

Are there any benefits to being in the research project?

The research may allow for the development and improvement of educational programs and build our understanding of best practice for online delivery of creative Scitech STEM activities.

Are there any risks, side-effects, discomforts or inconveniences from being in the research project?

There are no foreseeable risks from this research project. Apart from you giving up your time, I do not expect that there will be any risks or inconveniences associated with taking part in this study. Any and all requirements and guidelines relating to COVID-19 (e.g. mask wearing, hand sanitisation, physical distancing) will be adhered to during the observations.

Who will have access to my information?

The information collected in this research will be re-identifiable. This means that any information I collect that can identify you will stay on the information I collect and will be treated as confidential and used only in the project unless otherwise stated. I can let others know this information only if you say so or if the law says I need to. When the information is analysed and published, any identifying features will be removed (e.g. faces will be blurred). You will be referred to using a made-up name or code. The following people will have access to the information we collect in this research: the research team and, in the event of an audit or investigation, staff from Curtin University Office of Research and Development.

All information and electronic data will be password-protected and backed up onto Curtin University's secure electronic Research Drive. Hard copy data will be in locked storage and securely destroyed once digitised. As required by the Western Australian University Sector Disposal Authority, the information we collect in this study will be kept under secure conditions at Curtin University until children involved reach 25 years old then it will be destroyed. The results of this research, as well as de-identified still images and transcribed quotes from participants, may be presented at conferences or published in professional journals. They will also be published as part of Kimberly Maslin's PhD thesis. You will not be personally identified in any results that are published or presented.

Will you tell me the results of the research?

I will write to you at the end of this phase of the research (about 6 months after the observation) and let you know the results of the research. Results will not be individual but based on all the information we collect and review as part of the research.

Do I have to take part in the research?

Taking part in a research project is voluntary. It is your choice to take part or not. You do not have to agree if you do not want to. If you decide to take part and then change your mind, that is okay, you can withdraw from the project. If you choose not to take part or start and then stop the study, it will not affect your relationship with your employer or the university. If you choose to leave the study I will use any information collected unless you tell us not to.

What happens next and who can I contact about the research?

Children's creativity during online STEM

If you have any further questions or would like to contact the researchers, please email Kimberly Maslin kimberly.maslin1@postgrad.curtin.edu.au or the research supervisor (CI) A/Professional Karen Murcia karen.murcia@curtin.edu.au.

To provide consent to participate in this research project, please complete the Consent Form and return to Kimberly Maslin via email (kimberly.maslin1@postgrad.curtin.edu.au).

Curtin University Human Research Ethics Committee (HREC) has approved this study (HREC number HRE2022-0342). Should you wish to discuss the study with someone not directly involved, in particular, any matters concerning the conduct of the study or your rights as a participant, or you wish to make a confidential complaint, you may contact the Ethics Officer on (08) 9266 9223 or the Manager, Research Integrity on (08) 9266 7093 or email hrec@curtin.edu.au.

Appendix 19 Scitech Consent Form

Children's creativity during online STEM

CONSENT FORM FOR SCITECH

HREC Project Number:	HRE2022-0342
Project Title:	Fostering children's creativity with STEM activities in online learning environments
Chief Investigator:	Dr Karen Murcia, Associate Professor, School of Education
Student researcher:	Kimberly Maslin
Version Number:	1
Version Date:	26/05/2022

- I have read the information statement version listed above and I understand its contents.
- I believe I understand the purpose, extent and possible risks of my involvement in this project.
- I voluntarily consent to take part in this research project.
- I consent to being audio and video recorded for the purposes of this research.
- I have had an opportunity to ask questions and I am satisfied with the answers I have received.
- I understand that this project has been approved by Curtin University Human Research Ethics Committee and will be carried out in line with the National Statement on Ethical Conduct in Human Research (2007).
- I understand I will receive a copy of this Information Statement and Consent Form.

Participant Name	
Participant Signature	
Date	

Appendix 20 Semi-structure interview question schedule

Curtin University

Children's creativity during online STEM

Semi-Structured interview guide

As a semi-structured interview, the responses and discussions that occur in the individual session will guide the way the interview proceeds. Additionally, observations made during the activities may influence the questions which are asked in the interviews. However, the key questions and 'signposts' for the interview have been indicated in bold below.

Child interview (classroom STEM activities)

Introduction

Thank you for talking with me today. I am looking forward to hearing about some of the activities you have been doing in class.

We are going to look at some video recordings I made when I visited you recently in the classroom – do you remember that? You were participating in [STEM Activity] with [Teacher]. I am going to ask you some questions about that activity, and about creativity. There aren't any right or wrong answers – I'm interested in your thoughts and experiences.

Before we start, I want to remind you that

- If you want to pause or stop this interview at any time, you can just say so. If you don't want to answer a particular question, you can say so. We will just move onto another question instead.
- If it's ok with you, I am going to audio record our discussion so that I'm not distracted by taking notes. Do you know how an audio recorder (app) works [show on phone the first time]. No one apart from myself, and my research team will hear this recording. When I share your answers with others, I will not use your name.
- I'm going to give you these cards [assent cards]. [Explain how they should use them red/green].
- We are going to talk for about 20 minutes.

Do you have any questions about what I've just said? Is it ok for me to turn on the recorder now? [Child] can you use your cards to show me whether it's ok for me to ask you some questions and record you now?

Note: these questions represent the main themes to be discussed with the participants. As a semi-structured interview, it is expected that further prompts and follow-up questions will be used as the interview progresses. The language used will be tailored to suit the capabilities of the child being interviewed.

Establishing rapport

Can you tell me something fun that you did at school today?

Observation videos

I'm going to show you some of the video I recorded when I was observing you a few weeks ago. Do you remember this? Can you remind me of what you had to do?

Using video recordings and self-reflections as prompts, the child will be asked to talk about what they were trying to achieve or how they were doing something. These questions will be informed by the observations that have been made in the observation phase.

- Creative behaviours
  - What was tricky about this thing you're trying to do here?
  - How did you try to solve the problem?
  - What do you think you could do differently next time?

- Feelings about the STEM activity
    - [Child] you look/sound really [excited/happy/confused/frustrated/etc.] here. Can you tell me what was making you feel that way?
    - I can see you [doing something] here. What were trying to do there?
    - I can see [an impact of physical or online environment] happened here. How did you feel about this?
    - Can you tell me what you enjoyed about this activity? Was there anything you didn't enjoy?

Experience of the online delivery

For interviews about the online activities

- How did it feel to participate in the [workshop/show] online, instead of face-to-face?
- Was there anything about participating online that you didn't enjoy?
- Was there anything about participating online that you did enjoy?

Conclusion

Thank you for talking to me today, [child]. I had a really good time and you've helped me a lot in understanding more about your experience with this activity! You have been very important in helping with my research, so thank you very much for sharing with me.

Educator Interview (classroom STEM activities)

One interview, following all the classroom-based STEM activities

Introduction

Thank you for agreeing to participate in this interview. It's helpful to be able to talk to you to get a better understanding of your experiences of creativity, online learning and STEM.

I'm going to ask you some questions about the Scitech STEM activities your class has participated in recently and about creativity. There aren't any right or wrong answers – I'm interested in your thoughts and experiences.

You've seen the information sheet about this interview and signed the consent form but just so we're both clear, I'm going to remind you of the key points.

- Participating in this study is voluntary and you can stop participating whenever you choose. If you stop participating that's completely fine – it won't have any negative impact on your employment or with Curtin University.
- If you want to pause or stop the interview at any time, you can just say so. If you don't want to answer a particular question, you can say that too. We will just move onto another question instead.
- With your permission, I am going to audio record our discussion so that I'm not distracted by taking notes. Everything we talk about here will be confidential, which means no one outside the research team is going to see your name or know what you personally said. Any information I include in my report or publications will use a made-up name or code, including the name of the school.
- We're going to talk for between 45 – 60 minutes – we won't go any longer than that.

Do you have any questions about what I've just explained? Is it ok for me to turn on the recorder now?

Note: these questions represent the main themes to be discussed with the participants. As a semi-structured interview, it is expected that further prompts and follow-up questions will be used as the interview progresses. The language used will be tailored to suit the capabilities of the child being interviewed.

Establishing rapport

How long have you worked here at [school]? What do you enjoy about working with the Year 1 class?

Experience of the online delivery

I am going to start by asking you some questions about the two Scitech Live Shows that your class participated in online. I will then ask you some similar questions about the Scitech workshop your class participated in online. Finally, I will ask you some questions about teaching STEM to your class online versus in person.

Live Shows

- How did it feel to have your class participate in Scitech's Live Shows online, instead of face-to-face?
- Were there any challenges to coordinating and/or implementing the online Live shows?
- Was there anything about participating online that you enjoyed? Can you see benefits to the online delivery of Scitech's Live shows?
- How do you feel the online delivery impacted on the children's ability to be creative?
- What suggestions would you have for Scitech's future online delivery of their live shows?

Workshops

- How did it feel to have your class participate in Scitech's workshops online, instead of face-to-face?
- Were there any challenges to coordinating and/or implementing the online workshops?

Children's creativity during online STEM

- Was there anything about participating online that you enjoyed? Can you see benefits to the online delivery of Scitech's workshops?
- How do you feel the online delivery impacted on the children's ability to be creative?
- What suggestions would you have for Scitech's future online delivery of their STEM workshops?

Face-to-face vs. Online

- What differences did you notice in [focus children] as they participated in the online STEM activities, compared to when you deliver STEM activities in person? [engagement, results, creativity, behaviour]
- How do you feel the delivery of the STEM activities impacted on the children's creativity?

Conclusion

Thank you for talking to me today. It's really helped me understand more about the delivery of Scitech's STEM activities in online environments. You have been very important in helping with my research, so thank you very much for giving up your time in this way.

Scitech Facilitator Interview

Introduction

Thank you for agreeing to participate in this interview. It's helpful to be able to talk to you to get a better understanding of your experiences of creativity, online learning and STEM.

I'm going to ask you some questions about the Scitech STEM you facilitated recently and about creativity. There aren't any right or wrong answers – I'm interested in your thoughts and experiences.

You've seen the information sheet about this interview and signed the consent form but just so we're both clear, I'm going to remind you of the key points.

- Participating in this study is voluntary and you can stop participating whenever you choose. If you stop participating that's completely fine – it won't have any negative impact on your employment or with Curtin University.
- If you want to pause or stop the interview at any time, you can just say so. If you don't want to answer a particular question, you can say that too. We will just move onto another question instead.
- With your permission, I am going to audio record our discussion so that I'm not distracted by taking notes. Everything we talk about here will be confidential, which means no one outside the research team is going to see your name or know what you personally said. Any information I include in my report or publications will use a made-up name or code.
- We're going to talk for between 30-60 minutes – we won't go any longer than that.

Do you have any questions about what I've just explained? Is it ok for me to turn on the recorder now?

Note: these questions represent the main themes to be discussed with the participants. As a semi-structured interview, it is expected that further prompts and follow-up questions will be used as the interview progresses. The language used will be tailored to suit the capabilities of the child being interviewed.

Establishing rapport

How long have you worked at Scitech? What is your favourite part about delivering [show/workshops]?

Experience of the online delivery

- How did it feel to deliver the [show/workshop] online, instead of face-to-face?
- Were there any challenges to coordinating and/or implementing the online [show/workshop]?
- Was there anything about delivering online that you enjoyed? Can you see benefits to the online delivery of Scitech's Live shows?
- What suggestions would you have for Scitech's future online delivery of live [shows/workshops]?
- How do you feel the delivery of the STEM activities impacted on the children's creativity?
- Could you see examples of the children demonstrating creativity? How did you know?

Conclusion

Thank you for talking to me today. It's really helped me understand more about the delivery of Scitech's STEM activities in online environments. You have been very important in helping with my research, so thank you very much for giving up your time in this way.

Caregiver/child interview

Following the after school online STEM Club

Introduction

Thank you for agreeing to participate in this interview. It's helpful to be able to talk to you both to get a better understanding of your experience in the after school online STEM club.

I'm going to ask you some questions about the after school online STEM club and about creativity. There aren't any right or wrong answers – I'm interested in your thoughts and experiences. [Child] we are also going to look at some video recordings I made when I visited you – do you remember that? You were participating in [Week #] of the after school online STEM club.

You've seen the information sheet about this interview and signed the consent form but just so we're all clear, I'm going to remind you of the key points.

- Participating in this study is voluntary and you can stop participating whenever you choose.
- If you want to pause or stop the interview at any time, you can just say so. If you don't want to answer a particular question, you can say so. We will just move onto another question instead.
- With your permission, I am going to audio record our discussion so that I'm not distracted by taking notes. Everything we talk about here will be confidential, which means no one outside the research team is going to see your name or hear your answers. Any information I include in my report or publications will use a made-up name or code.
- I'm going to give [Child] these cards [assent cards]. [Explain how child should use them red/green]. But if you think that [child] wants to stop talking but doesn't remember the cards, then you [caregiver] can tell me so.
- We're going to talk for about 30 minutes.

Do you have any questions about what I've just said? Is it ok for me to turn on the recorder now? [Child] can you use your cards to show me whether it's ok for me to ask you some questions and record you now?

Note: these questions represent the main themes to be discussed with the participants. As a semi-structured interview, it is expected that further prompts and follow-up questions will be used as the interview progresses. The language used will be tailored to suit the capabilities of the child being interviewed.

Establishing rapport

Note: the child will have been interviewed with me twice before this point

Caregiver – just so I'm talking to you both using the names you prefer, what does [child] usually call you? (e.g. mum, nanna, daddy)

Child – can you tell me something fun that you did at school today?

Experience of the online after school STEM Club

Caregiver – Can you tell me about the experience of participating in the after school online STEM Club?

- Compared to a face-to-face activities, how much do you feel your child got out of this experience?
- Did you encounter any challenges with the club being delivered online?
- Could you see examples of your child demonstrating creativity? How did you know?

Child – Can you tell me about participating in the after school online STEM club?

- What was your favourite part of the STEM club?
- How did it feel to participate in the STEM club online, instead of face-to-face?
- Was there anything about participating online that you didn't enjoy?
- Was there anything about participating online that you did enjoy?

Observation videos

I'm going to show [child] some of the video I recorded when I was observing them a few weeks ago. Do you remember this, [child]? what did you think about the activity that you were doing here? Can you remind me and [caregiver] about what you had to do?

Using video recordings and self-reflections as prompts, the child will be asked to talk about what they were trying to achieve or how they were doing something. These questions will be informed by the observations that have been made in the observation phase.

- Creative behaviours
    - What was tricky about this thing you're trying to do here?
    - How did you try to solve the problem?
    - What do you think you could do differently next time?
- Feelings about the online STEM club
    - [Child] you look/sound really [excited/happy/confused/frustrated/etc.] here. Can you tell me what was making you feel that way?
    - I can see you [doing something] here. What were trying to do there?
    - I can see [an impact of home environment] happened here. How did you feel about this?

Conclusion

Thank you for talking to me today, [child and caregiver]. I had a really good time and you've helped me a lot in understanding more about what your experience with the online STEM club! You have been very important in helping with my research, so thank you very much for giving up your time in this way.

Appendix 21 Esperance Weekender

Phone: 9071 6555

Colin de Grussa MLC

Member of the Legislative Council

Esperance weekender

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STEM club for schoolkids

Photo: Prathamesh Deshpande

Our Lady Star of the Sea (OLSOTS) school signed up for Scitech's STEM Club, making it the first regional school in the State to benefit from this initiative. Here, we see Braxtyn Rose and Sascha Francis working on making an axle, after learning about potential energy and beginning car construction in the first session of the Club last week. More on page 7.

Inside stories

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P4 New gun laws

VOTE YES! yes23

P6 Esperance votes

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