# How Conceptual PlayWorlds Create Different Conditions for Children's Development Across Cultural Age Periods – A Programmatic Study Overview

Marilyn Fleer*

*PlayLab, School of Educational Psychology and Counselling,
Faculty of Education, Monash University, Melbourne, Australia*

* Corresponding author: E-mail: marilyn.fleer@monash.edu

**ABSTRACT**

**Background.** As educational systems around the globe increasingly focus on delivering outcomes and evidence of early childhood education, questions are asked about how increasing the cognitive load on children in preschool settings impacts their development.

**Objective.** To better understand this problem, a five-year programmatic study was funded by the Australian Research Council with the objective of researching conceptual play as an intervention, studying imagination in play and imagination in science, engineering, and technology.

**Design.** The study design featured 3,000 teachers, 100 families, and 120 focus infants and toddlers in Australia who were followed for five years.

**Results.** The study is currently underway. This paper gives an overview and conceptualisation of the research, and the midterm findings. The project expects to generate new knowledge about the concept formation of infants, toddlers, and pre-schoolers under the conditions of a Conceptual PlayWorld in play-based settings and homes.

**Conclusion.** The projected outcomes are expected to include understanding about how concepts can be intentionally taught in play settings and learned at home for particular cultural age periods. Significant benefits will include increased knowledge of how exposure to these concepts in the formative years affects children's development.

*Keywords:* Play; imagination; Conceptual PlayWorlds; conceptual play; cultural age periods; cultural-historical theory; drama

**Highlights:**

- The nature of children's imagining of concepts changes over the different cultural age periods;
- Under the conditions of a Conceptual PlayWorld, imagination develops and play matures;

- Under the conditions of a Conceptual PlayWorld, teachers change from real relations to play relations, and this affords new kinds of practices and conditions for children's development;
- A Conceptual PlayWorld creates motivating conditions for girls' engagement in STEM in the early years.

**АННОТАЦИЯ**

**Актуальность.** Поскольку образовательные системы по всему миру все большее значение придают обучению в дошкольном детстве, встают вопросы о том, как увеличение когнитивной нагрузки на детей в дошкольных учреждениях влияет на их развитие.

**Цель.** Чтобы изучить указанную проблему, Австралийский Исследовательский Совет профинансировал пятилетнее программное исследование. Целью данного исследования является анализ концептуальной игры как особого типа обучения, с целью изучения воображения в игре и воображения в науке, инженерии и технологии.

**Дизайн.** В исследовании приняли участие 3000 учителей, 100 семей и 120 младенцев и детей младшего возраста из Австралии, за которыми наблюдали в течение пяти лет.

**Результаты.** В настоящее время исследование продолжается. В данной статье дается обзор и обоснование исследования, а также описываются промежуточные результаты. Проект предполагает получение новых знаний о формировании представлений у младенцев, детей младшего возраста и дошкольников в условиях концептуальных игровых миров в специальных игровых условиях и дома.

**Вывод.** Прогнозируемые результаты связаны с пониманием того, как можно обучать новым представлениям в специально созданных игровых условиях и дома для разных культурных возрастных периодов. Значительное преимущество проекта — расширение знаний о том, как знакомство с этими представлениями в годы становления влияет на развитие детей.

*Ключевые слова:* Игра; воображение; Концептуальные Игровые Миры; концептуальная игра; культурные возрастные периоды; культурно-исторический подход; драма

**Ключевые положения:**

- Характер понятийных представлений детей меняется в разные культурные возрастные периоды;
- В условиях Концептуального игрового мира развивается воображение, а игра созревает;
- В условиях Концептуального игрового мира учителя переходят от реальных отношений к игровым, и это создает новые виды практик и условия для развития детей;
- Концептуальный игровой мир создает мотивирующие условия для вовлечения девочек в STEM в ранние годы.

**RESUMEN**

**Introducción.** A medida que los sistemas educativos por todo el mundo se centran cada vez más en ofrecer resultados y pruebas de la educación de la primera infancia, surgen preguntas sobre cómo el aumento de la carga cognitiva en los niños en entornos preescolares afecta su desarrollo.

**Objetivo.** Para comprender mejor este problema, el Australian Research Council financió un estudio programático de cinco años con el objetivo de investigar el juego conceptual como intervención, estudiando la imaginación en el juego e imaginación en la ciencia, ingeniería y tecnología.

**Diseño.** El diseño del estudio contó con 3000 maestros, 100 familias y 120 bebés y niños pequeños en Australia que fueron seguidos durante cinco años.

**Resultados.** El estudio está actualmente en marcha. Este documento ofrece una descripción general y la conceptualización de la investigación, y los resultados de la mitad del período. El proyecto espera generar nuevos conocimientos sobre la formación de conceptos de bebés, niños pequeños y niños en edad preescolar en las condiciones de PlayWorlds conceptuales en entornos educativos y hogares basados en el juego.

**Conclusión.** Se espera que los resultados proyectados incluyan la comprensión de cómo los conceptos pueden enseñarse intencionalmente en entornos de juego y aprenderse en el hogar en períodos de edades culturales particulares. Los beneficios significativos incluirán un mayor conocimiento de cómo la exposición a estos conceptos en los años formativos afecta el desarrollo de los niños.

*Palabras clave:* Juego; imaginación; PlayWorlds conceptuales; juego conceptual; periodos de edad cultural; teoría histórico-cultural; drama; mundos de juego

**Destacados**

- La naturaleza de la imaginación de los conceptos por parte de los niños cambia a lo largo de los diferentes períodos culturales de edad;
- Bajo las condiciones de un PlayWorld conceptual la imaginación se desarrolla y el juego madura;
- Bajo las condiciones de un PlayWorld conceptual los maestros cambian de relaciones reales a relaciones de juego y esto brinda nuevos tipos de prácticas y condiciones para el desarrollo de los niños;
- Un PlayWorld conceptual crea condiciones motivadoras para la participación de las niñas en STEM en los primeros años.

**RESUME**

**Préalable**. Puisque les systèmes éducatifs du monde entier se concentrent de plus en plus sur la fourniture de résultats et de preuves de l'éducation de la petite enfance, des questions sont posées sur l'impact de l'augmentation de la charge cognitive sur les enfants en milieu préscolaire sur leur développement.

**Objectif**. Pour mieux comprendre ce problème, une étude programmatique de cinq ans a été financée par le Conseil australien de la recherche afin de rechercher le jeu conceptuel en tant qu'intervention explorant l'imagination dans le jeu et l'imagination dans les sciences, l'ingénierie et la technologie.

**Conception**. La conception de l'étude comprenait 3 000 enseignants, 100 familles et 120 nourrissons et tout-petits enfants qui commencent à marcher focalisés en Australie qui ont été suivis pendant cinq ans.

**Résultats**. Actuellement l'étude est toujours en cours. Cet article donne un aperçu et une conceptualisation de la recherche, ainsi que les résultats à mi-parcours. Le projet prévoit de générer de nouvelles connaissances sur la formation conceptuelle des nourrissons, des tout-petits enfants et des enfants d'âge préscolaire dans les conditions d'un monde de jeu conceptuel dans des environnements et des foyers basés sur le jeu.

**Achèvements**. Les achèvements projetés devraient inclure la compréhension de la façon dont les concepts peuvent être intentionnellement enseignés dans des environnements de jeu et appris à la maison pour des périodes d'âge culturel particulières.

Les avantages importants comprendront une meilleure connaissance de la façon dont l'exposition à ces concepts au cours des années de formation affecte le développement des enfants.

*Mots-clés*: Jeu; l'`imagination; les « PlayWorlds» conceptuels; jeu conceptuel; périodes d'âge culturel; la théorie historico-culturelle; le drame; les mondes de jeu

**Points principaux:**

- La nature de l'imagination des concepts des enfants change au fil des différentes périodes d'âge culturel;
- Dans les conditions d'un « PlayWorld « conceptuel, l'imagination se développe et le jeu mûrit;
- Dans les conditions d'un « PlayWorld « conceptuel, les enseignants passent de relations réelles à des relations de jeu, ce qui offre de nouveaux types de pratiques et de conditions pour le développement des enfants;
- Un « PlayWorld « conceptuel crée des conditions motivantes pour l'engagement des filles dans les STIM (science, technologie, ingénierie et mathématiques) dans les premières années de vie.

## Introduction

A focus on the cognitive development of young children in preschool settings has emerged over time as greater attention is given to the importance of this particular cultural age period by governments around the globe. Learning outcomes are now stated explicitly in curricula by many educational systems, and policymakers have increased their expectations for the learning of concepts by preschool children. This had placed new demands on early childhood teachers and raised expectations by families and the public for an increased cognitive load on children. Interestingly, the original research that propelled the prominence and importance of the early childhood period featured play as the leading activity of the preschool child. Yet in some countries, play as the source of development for the preschool child has diminished in time and prominence in teacher programs. More needs to be known about balancing play and learning (see Veraksa, Sheridan, & Colliver, 2021).

The current policy context and intensified educational push have resulted in a resurgence of play research. This paper contributes to the current interest by presenting an overview of a five-year programmatic study into the play and learning of STEM concepts by children in the birth to five/six-year cultural age period. The programmatic study showcased in this paper is grounded in cultural-historical theory and L.S. Vygotsky's view of child development.

The central problem of the study is to understand the relations between imagination in play and imagination in STEM through an intervention called Conceptual PlayWorld, and then to determine what this means for teacher pedagogy and children's development across the cultural age periods from infancy to school age. The overarching results could make a significant contribution to understanding the effects of an increased cognitive load on children.

To achieve the objectives of this paper, a discussion of child development is followed by an overview of the programmatic study design, and highlights of what has

been learned to date. The paper concludes by projecting forward and discussing the future needs for play research.

### *Background to the Programmatic Research*

What has emerged from the background research into the relations between play and STEM learning is, first, a cultural-historical synthesis of these two binaries of play and learning as Conceptual Play (Fleer, 2011a). Second, further foundational research into STEM learning and play has brought forward the Conceptual Play-World as a teaching model (Fleer, 2018a; 2019a) which was iteratively refined across the areas of STEM. For example, Scientific PlayWorlds (Fleer, 2017a), Digital Play-Worlds (Fleer, 2017b; 2017c), and Engineering PlayWorlds (Fleer, 2020a). The result was the Conceptual PlayWorld intervention and this is foundational for the programmatic research reported through a series of studies shown in *Tables 2* to *4*. Third, specific attention has been directed to the place of girls and women in STEM (Fleer, 1990; 2021a). This has been taken forward through additional studies reported in *Table 3* (Stephenson, Fleer, & Fragkiadaki, 2021; Stephenson, Fleer, Fragkiadaki, & Rai, 2021a, 2021b; Utami, Fleer, & Li, 2021). Prior research into the reconceptualization of research into executive functions in the context of playworlds also provided additional insights into play and learning in preschool settings. See https://www.monash.edu/conceptual-playworld for the characteristics and video practices of the Conceptual PlayWorld model.

### *Cultural Age Periods*

In order to understand the current changing conditions of the preschool child, it is necessary to return to Vygotsky's (1998) original theorisation of child development. By better understanding the transition points over the cultural age periods of the child, we can conceptualise "crisis" as a scientific construct and use it for analysing the new developmental conditions created. We are specifically interested in the differing cognitive load afforded during conceptual learning across the different cultural age periods.

**Crisis** is a powerful cultural-historical concept that simultaneously considers both the social situation of the child and what Vygotsky called "the social situation of their development." This matters because the current social situation of the child, with its greater cognitive load, creates new developmental conditions that our programmatic research sought to better understand. Bodrova (2008) has rightly argued over the years how in the US context, with its "schoolification" of preschools (discipline outcomes with more school like practices), this social situation has negatively affected children's ability to engage in imaginary play. Her work signalled early on some important changes in the social situation of children in the US, and the corresponding impact on the children's social situation of development. Like the canary in the coal mine, children not knowing how to imaginatively play suggested that a serious problem was emerging.

According to Vygotsky (1966), **imaginary play** is a key characteristic of the activity and thinking of the preschool child. But we must conceptualise this activ-

ity within the whole system of a child's development, and this means exploring a child's leading activity at different moments along the cultural age periods and studying the dynamics of the social situations within which crises or transitional points emerge. In so doing, it becomes possible to analyse how the current changing context affects children's development, and what researchers and educational systems need to better understand so that the scenario described by Bodrova becomes less widespread.

Vygotsky (1998) did not focus on biological milestones as his method of dividing children's development. He suggested that most approaches to child development took an evolutionary perspective, where single traits of observable biological changes were the main measure of development. Here he suggested that "development is nothing other than realization, modification, and combination of deposits [sic; should be translated as "combination of inborn potentials"—ed.]" or it is viewed as "a continuous process of self-propulsion" in which "Nothing new develops…" (p. 190). In his revolutionary view of development, however, he suggested that "We must consider its dynamics and the dynamics of transitions from one age level to another" (p. 190). As a child enters into a period of crisis, rather than noting disruptions and changes, Vygotsky argued that we must pay attention to the fact that the child loses interest in activities s/he was once interested in. Vygotsky pointed to behaviour as indicators, whereby "the child becomes relatively difficult due to the fact that the change in the pedagogical system applied to the child does not keep up with the rapid changes in his [sic] personality" (pp. 193–194). For example, Mariane Hedegaard (2009) showed how a preschool child's leading activity to learn, as was the dominant practice in the home, created tension in the kindergarten because the teacher's pedagogical practices fostered a warm and cosy play environment, with no pressure for learning to write or read. The child's motive for learning was not being supported, and his relations with his kindergarten teacher became difficult.

Vygotsky (1998) further argued that the "general structure of consciousness changes at each given age" (p. 197). He pointed to how each cultural age period was "characterized mainly by a certain system of relations and dependences between its separate aspects and separate forms of the individual's activity" (p. 197). Vygotsky conceptualised these into a general theory of child development, where neoformations and critical ages of the peaks and troughs of the crisis emerge. His general theory of periodisation clustered around: Crisis of the newborn; Infancy (2m – 1yr); Crisis of age one; Early childhood (1–3yrs); Crisis at age three; Preschool age (3–7yrs); Crisis at age seven; School age (8–12yrs); Crisis at age 13; Age of puberty (14–18yrs); Crisis at age 17.

The motive orientation of the child changes across cultural age periods and this is captured by a "dialectical process in which a transition from one stage to another is accomplished not along an evolutionary, but along a revolutionary path" (p. 193). This dialectical process is described as, "Critical periods alternate with stable periods and [these] are **turning points** in development" (p. 193; my emphasis). Important in our research has been noting the changes or turning points of development under the new conditions of STEM learning.

Vygotsky conceptualised his theory of child development broadly into these cultural age periods, with the characteristics of each period involving a particular social situation of development. This conception captured through the term "cultural age periods" is distinguished in this paper from a focus on the biological or passport age of the child and the associated milestones of development normally presented in Western contexts. But Vygotsky's theorisation was done during the historical period of the former Soviet Union, at a particular point in time where when travel, the Internet, YouTube, and smartphones had not entered into the daily lives of children, families, and educational settings. These phenomena give access to broader and richer cultural experiences for expanded conceptual thinking, which would be absent from theorisation about the cultural age periods Vygotsky presented. However, still relevant is his premise that the transition from one leading activity and system of human relations to another constituted a whole reconstruction in which the child's relation to his or her environment changes. It is this change in the child's relationship to the environment that is of interest in our research. Vygotsky (1998) conceptualized this as *the social situation of development:*

> …at the beginning of each age period, there develops a completely original, exclusive, single, and unique relation, specific to the given [cultural] age, between the child and reality, mainly the social reality, that surrounds him [sic]. We call this relation *the social situation of development* at a given age. The social situation of development represents the initial moment for all dynamic changes that occur in development during the given period. It determines wholly and completely the forms and the path along which the child will acquire ever newer personality characteristics, drawing them from the social reality as from the basic source of development, the path along which the social becomes the individual. Thus, the first question we must answer in studying the dynamics of any age is to explain the social situation of development (p. 198).

Vygotsky also suggested that when studying children's social situation of development, it becomes important to ask how neoformations develop from the life of the child in his or her social situation. With changing societal values towards more learning in preschool, and the introduction of new institutional contexts that support these values by increasing the cognitive load of children in play-based settings, how do these new social situations for learning affect children's development? As noted by Vygotsky (1998), "**Pedagogy during the critical ages is least developed in practical and theoretical respects**" (pp. 193–194; my emphasis), and this question remains relevant today, because societies continue to change, and new institutional practices emerge and bring forward new conditions for children's development.

## Methods

The goal of the programmatic research was to understand children's development in play-based settings where an intervention of a STEM PlayWorld was introduced. Initially drawing inspiration from Gunilla Lindqvist's playworld (Lindqvist, 1995),

a model was developed from foundational research into play and learning of STEM (Fleer, 2018a). Known as a Conceptual PlayWorld, storybooks and drama were used to create new conditions for children's play. A STEM PlayWorld brings drama into the adventures that are role-played by children and teachers. But unlike in other play-worlds (see Fleer, 2020a), a problem arises in the play that needs a STEM solution – such as, how to design an escape plan in the role-play of Robin Hood. But different cultural age periods demand different kinds of drama and social relations, as well as new kinds of pedagogical practices for collective play and imagining. This was an important focus during the research period.

In order to realise complex research over a five-year period, the programmatic research was conceptualised as three pillars of activity. An overview of each pillar follows (also see Fleer, Fragkiadaki, & Rai, 2020a).

### *Pillar 1: Foundational Research into Concept Formation in STEM across Cultural Age Periods*

This research is following a cohort of 130 infants from diverse early childhood settings over five years, in order to gain insights into the unique nature of imagination in STEM and how it changes in relation to the different cultural age periods and the learning contexts of infants, toddlers, and pre-schoolers. The goal is to deepen our understanding of what conceptual play is for infants and toddlers, and how it is supported during the different cultural age periods in diverse play-based settings.

### *Pillar 2: Generate Scholarly Knowledge about How Families Create the Conditions for Creative Cognition*

Using digital tools to document children's play and everyday interactions related to STEM at home (e.g., cooking, building, washing) gives insights into what STEM concepts mean for families and gives deeper understanding about the nature of children's cultural development of STEM concepts in the home. The focus of this pillar is understanding how gender, culturally and linguistically diverse children (CALD), inclusion, socioeconomic status (SES), and geography shape possibilities in STEM experiences in the home and community. The research also examines how family pedagogy productively contributes to STEM thought in young children. In building upon a successful digital ethnographic approach for researching the everyday lives of families (Hedegaard & Fleer, 2013) and government-funded research for improving conceptually oriented interactions in families and childcare centres (Fleer & Raban, 2006), 100 children and their families from different CALD contexts and geographies are being followed for 12 months (families will also use a protocol and app to digitally capture activities and family pedagogy between visits). A second set of families have been participating in the Conceptual PlayWorld intervention through zoom technology with a storyteller. Cohorts are drawn from playgroups, visitors to the botanical gardens, and other such community groups. The study is ongoing, and the results are not reported in this paper.

### Pillar 3: A National Evidenced-Based Model of Intentional Teaching of STEM for Play-Based Settings

The studies from Pillars 1 and 2 contribute to understanding how adults create the conditions for creative cognition using the STEM Playworlds model for infants, toddlers, and pre-schoolers. How educators intentionally teach STEM concepts through a STEM Playworlds model will vary across Australia due to the unique characteristics of geography, educator expertise and support, SES, etc. Determining how STEM learning is best promoted in play-based settings is key for building teacher confidence and competence for particular cultural age periods, where a diversity of contexts and experiences shapes how children engage in STEM.

A total of 3,000 diploma and degree-qualified early childhood teachers were targeted and are currently being surveyed using Qualtrics, and from this cohort a subset of 150 teachers attending professional development (PD) is currently being studied. This in-depth study of the teachers is currently underway.

### Analysis

Analysing data from the individual pillars, as well as bringing together the data from across the pillars, demands a complex set of concepts. Within Vygotsky's system of concepts are powerful interrelated analytical concepts, as shown in *Table 1*, that were and are currently being used. Some practice examples of data are also showcased in Table 1.

Table 1

*The theoretical and analytical framework guiding the programmatic research based on previous foundational research*

| Research Pillars | STEM concept formation over cultural age periods | Family conditions to promote STEM thought | Intervention of a Conceptual PlayWorld in early childhood play-based settings |
|---|---|---|---|
| **Research Questions:** | What is the nature and development of conceptual thinking in STEM during infancy, toddlerhood, and the preschool years? | What are the pedagogical practices and family narratives that support STEM thinking in informal family and community settings? | How does a Conceptual PlayWorld model promote teacher confidence and competence in STEM teaching in play-based settings? |
| **Background research:** | Infant research of STEM concepts about the Earth and beyond (Hao & Fleer, 2017); toddler and preschooler thinking in design technologies and science (Fleer, 1991; 1992;1995; Fleer & Beasley, 1991); as collective practices (Fleer & March, 2015) | Family pedagogy (Hao & Fleer, 2016; Hedegaard & Fleer, 2013); STEM thinking (Sikder & Fleer, 2014; 2018) and STEM motives (Gomes & Fleer, 2017) | Teacher confidence & competence when engaged in Conceptual PlayWorld (Fleer, March & Gomes, 2014; Gomes & Fleer, 2018) in contexts of gendered STEM (Fleer, 1990) |

| Research Pillars | STEM concept f ormation over cultural age periods | Family conditions to promote STEM thought | Intervention of a Conceptual PlayWorld in early childhood play-based settings |
|---|---|---|---|
| **Cultural-his-torical concepts with examples of practices/con-ceptual thinking in STEM:** | Vygotsky's (1966) concep-tion of play: Creates an imaginary situation (adult/child); "This spot (pointing) is our worm hole, and we are worms" (see Fleer, 2017a). Child changes the meaning of visual field, such as when objects like a stick become a worm. | Families invite children to imagine being a rocket going around the Earth (Hao & Fleer, 2017). | Teacher confidence & competence are shown as they move from a focus on STEM knowledge to creating an authentic problem that children want to solve in their play (Fleer, Fragkiadaki, & Rai, 2022). |
| | Vygotsky's (1997) dialectical conception of interpsychological and intrapsychological functioning: Children signal (intra-psychological) they are in the imaginary situation through words and ges-tures already presented through the story when it was read or told (inter-psychological) | Play is jointly enacted with parents *and later* independently enacted | Kravtsov & Kravtsova (2010) concept of play — the "dual perspective" of the player as participant in play and as a person experiencing the emo-tions of the play. Being inside the imagi-nary play, taking a role (Fleer, 2015). Conceptual interactions (Fleer, 1991; 1992; 1995) and pedagogical position-ing (Devi, Fleer & Li, 2018; 2020; Fleer, 2015) |
| | Metacommunicative lan-guage (Bretherton, 1984) in collective play (Fleer, 2011a); Underscores actions or words; High inflection at end of sentence; Uses words such as, "Pretend I was...." | Wonder: "I wonder what might happen if...." Imag-ine: "Imagine if you were a...." Doing: "what would you do if …?" Evaluate: "Do you think there re-ally are…?" (Fleer, 2017a) | Being deliberately in frame, setting problems up inside the imaginary play (Fleer, 2017a; 2014). For example, "Why/how do worms make their cast like this (looking/crawl-ing in a fabric child-sized worm cast)?" |
| | Cultural-historical con-ception of imagination in science (Vygotsky, 2004); Evidence of imagining the relations between observable and non-observable contexts/con-cepts – e.g., magnification – shrinking down the rabbit hole to investigate (Fleer, 2017a) | Adults pay attention to children's talk about what they observe in every-day life (e.g., cooking – steaming, melting) | Adults use conjunctions to blend story lines to help build STEM nar-rative, such as "and" or "then they went..." (Fleer, Fragkiadaki & Rai, 2021a) |

## Results

Although the research is midway through the five-year programmatic study, there have been significant developments in understanding how imagination in play and imagination in STEM have affected the children's development. A summary of the key findings is presented in *Tables 2–5*, alongside a discussion of the collective significance regarding the impact of increasing the cognitive load of children across cultural age periods.

In previous research, it was determined that very little is known about how infants, toddlers, and pre-schoolers engage in conceptual thinking in STEM. Much of the previous research has been oriented to school contexts, leaving a gap in comprehensive understanding of how children in play-based settings think and act scientifically (Fleer, 2017a), technologically (Fleer, 2016), and in relation to engineering (Fleer, 2020a). *Table 2* adds to this through a comprehensive review of the literature (O'Connor, Fragkiadaki, Fleer, & Rai, 2021), which identified that the focus of research on the infant and toddler period has been associated with the processes, but not necessarily with scientific thinking. However, when infants and toddlers do participate in a STEM Conceptual PlayWorld, different conditions are created that bring infants and toddlers together in emotionally charged play situations with drama and action, and where a form of conceptual reciprocity emerges through the drama of the story and joint adventures (Fleer et al., 2020a). Early findings are also showing that a sense of collective imagining in rudimentary STEM emerges (Fragkiadaki, Fleer, & Rai, 2021a; 2021b; 2021c). We now know how imagination as a psychological function emerges in infancy in group settings, when a Conceptual PlayWorld is used by teachers. We found that a) by participating in the imaginary situation as a play partner, teachers introduced an advanced form of imagination into the infants' environment and invited the infants to join collective forms of imagining; b) infants recognized and responded to the invitations for collective imagining coming from the teacher and their peers through imitation and the use of diverse signs; c) the infants developed a motive orientation to the collective imagining through experiencing the imaginary situation within the activity settings; and d) the infants' collective imagining with the adult was enriched and extended as well, and was developed in dialectic interrelation with the transformation of the group relations within the activity settings (Fragkiadaki et al., 2021b). This is in keeping with previous research with preschool-aged children, where a Conceptual PlayWorld creates a sense of collective engineering play (Fleer, 2020a) and a form of theoretical thinking and motive orientation to STEM emerges during older children's conceptual play (Fleer, 2011a; 2020a). When taken together, it seems that a sense of collectiveness is key for building imagination, and early forms of collective imagining appear during infancy under the conditions of a Conceptual PlayWorld (Fragkiadaki et al., 2021b). But more needs to be known about the everyday phenomena that engage infants in collective imagining and how this orientation to a phenomenon changes into a motive orientation to particular STEM concepts later in the preschool period.

Table 2

*The nature of children's imagining of concepts changes over the different cultural age periods*

| Overview | Impact | Reference |
|---|---|---|
| This review identified a gap in the literature regarding infants' and toddlers' thinking in relation to science concepts. More is known about what four- and five-year-olds think. | Most research has examined the *process* of concept formation in the cultural age period from birth to three years, rather than how infants and toddlers develop science concepts. | O'Connor, G., Fragkiadaki, G., Fleer, M., & Rai, P. (2021). Early childhood science education from 0 to 6: A literature review. *Education Sciences*, *11*(4). https://doi.org/10.3390/educsci11040178 |
| This research focused on a Conceptual PlayWorld for infant and toddler learning in STEM and showed that these new pedagogical conditions in homes and in childcare centres created conditions for engagement and narrative in STEM. | A Conceptual PlayWorld in STEM was found to:<br>• Generate a narrative of a story that creates an intellectual and emotionally charged context which unites young children;<br>• Frame teachers' and families' child–adult interactions to intentionally and responsively support infants' initiatives;<br>• Generate conceptual reciprocity between the adults and young children during the story and throughout the STEM adventure. | Fleer, M., Fragkiadaki, G., & Rai, P. (2020). STEM begins in infancy: Conceptual PlayWorlds to support new practices for professionals and families. *International Journal of Babies and Parents Education, 7*(4), 29–33. |
| The study showed how teachers used a Conceptual PlayWorld to create collective imaginary situations and a sense of togetherness for infants and toddlers in childcare settings.<br>An embodiment of the story as expressed through the use of props and role-playing expanded infants' experience, supported a sense of togetherness, and at the same time developed infants' collective orientation in the group setting. | Generating a shared experience and sense of togetherness in a Conceptual PlayWorld was achieved by the teachers through:<br>• vibrant tone and changes in the sound of their voice, gestures, body language, and body positioning (e.g., walking slowly to avoid scaring the possum);<br>• narration with actions in the story, such as, *"Mummy possum and baby possum are sleeping together!"*<br>• directing talk to the infants while being in character to orient infants to the activity and the concepts;<br>• responding and amplifying child initiatives;<br>• props related to the storyline, e.g., children's book, set of puppets, objects in the story, such as a small hammer, open-ended diverse material props as a resource to inspire infants' joint actions to the imaginary situation; | Fragkiadaki, G., Fleer, M., & Rai, P. (2021). Collective Imagining: The early genesis and development of a sense of collectiveness during infancy. *Cultural-Historical Psychology*, *17*(3). 84–94. https://doi.org/10.17759/chp.2021170312 |

| Overview | Impact | Reference |
|---|---|---|
| | • props gave teachers access to the infants' imaginary play as well as keeping them in the imaginary play with the infants;<br>• conceptual orientation took place because teachers shifted the infants' focus from physical objects and the concrete spaces to a shared intellectual and abstract space. | |
| The research identified an early form of collective imagination during infancy as a result of participating in a *Conceptual PlayWorld*. | The study found that:<br>• teachers as play-partners in an imaginary situation introduced advanced forms of imagination to infants which motivated them into joint collective forms of imagining;<br>• infants recognised and responded to the collective imagining from the teacher through imitation and the use of diverse signs;<br>• infants developed a motive orientation to collective imagining in a Conceptual PlayWorld. | Fragkiadaki, G., Fleer, M., & Rai, P. (2021). The social and cultural genesis of collective imagination during infancy. *Learning, Culture and Social Interaction, 29.* https://doi.org/10.1016/j.lcsi.2021.100518 |
| The research into preschool children's engineering thinking showed that teachers in a Conceptual PlayWorld can orient children to engineering thinking, develop their engineering competence, and support a motive orientation to engineering. | The study identified that:<br>• Conceptual PlayWorlds with an engineering focus give a common experience to children to explore engineering problems, imagine and explore engineering solutions during child-initiated play;<br>• play actions became aligned and collective as children drew upon the same storyline, the same embodied experience, and the fiction and non-fiction resources;<br>• the collective alignment seemed to orient the children to each other in pursuit of their imagined engineering PlayWorlds and to collectively solve the play problem;<br>• when the themes of children's play change through "as if" imaginary narratives, their play actions become more complex as evidenced through "as if" engineering solutions; | Fleer, M., (2020). Studying the relations between motives and motivation – How young children develop a motive orientation for collective engineering play. *Learning, Culture and Social Interaction,* 24. https://doi.org/10.1016/j.lcsi.2019.100355 |

| Overview | Impact | Reference |
|---|---|---|
|  | • collective imaginary play at engineering showed how children drew upon engineering concepts and made them personally meaningful when playing; <br> • the motivating conditions of the engineering PlayWorld built engineering competence, and this competence seemed to amplify the children's collective engineering actions in their play. This in turn appeared to orient the children towards a motive for engineering play. |  |

The second preliminary finding to emerge from the research being undertaken in the PlayLab is related to better understanding the impact of the new pedagogical conditions created by the intervention of a Conceptual PlayWorld. In *Tables 3* to *5*, the impact is studied in relation to children's imaginary play and conceptual STEM thinking (*Table 3*), teacher development (*Table 4*), and girls' engagement in STEM (*Table 5*).

Table 3

*Under the conditions of a Conceptual PlayWorld, imagination develops and play matures*

| Overview | Impact | Reference |
|---|---|---|
| In a Conceptual PlayWorld, teachers introduced mature forms of play and their play actions positively interacted with children's real form of play, giving rise to new developmental conditions. | A Conceptual PlayWorld created developmental conditions for preschool children when teachers: <br> • took an active play role; <br> • changed their real relations as a teacher into play relations as a player; <br> • acted "as if" a character in the story, with the other teacher acting as the narrator, where mature forms of play became available to the children, and for longer periods; <br> • signalled metacommunicative actions, changed the meaning of objects and actions, and amplified emotionally dramatic moments; <br> • adopted play language when inside the imaginary situation, using conjunctions such as, "and" and "then" to build the storyline; | Fleer, M. (2021). How conceptual PlayWorlds in preschool settings create new conditions for children's development during group time. *Learning, Culture and Social Interaction*, 28. https://doi.org/10.1016/j.lcsi.2020.100438 |

| | | |
|---|---|---|
| | <ul><li>generated contradictions regularly through changing the meaning of objects and actions in the imaginary situation to give them a new sense;</li><li>simultaneously used different kinds of pivots, from using objects as pivots to using actions as pivots and using words in play to signal the sense of something.</li></ul> | |
| The study found that when children were involved in a Conceptual PlayWorld, some children created their own child-initiated PlayWorld during free choice time, suggesting that their experience creates motivating conditions for role-playing the new practices. | The study found that:<ul><li>children notice how teachers bring curriculum concepts into the preschool program;</li><li>children on their own could not bring out in their child-initiated play mature forms of the curriculum concepts introduced by teachers in the Conceptual PlayWorld;</li><li>collective play of children and teachers appears as a precondition for orienting children towards a shared everyday problem where concepts become personally meaningful.</li></ul> | Fleer, M. (2021). How an educational experiment creates motivating conditions for children to role-play a child-initiated playworld. *Oxford Review of Education, 48*(3), 364–379. https://doi.org/10.1080/03054985.2021.1988911 |
| The overall study of design and play of preschool children identified that imaginary play acted as the psychological function through which children made sense of the concept of design.<br>Play acted as a source of development of design. Play created the conditions for giving purpose to design. Play gave possibilities to extend children's designed solutions, but also to iteratively develop their design ideas.<br>When design concepts were introduced as part of the children's play, this gave a level of authenticity, a sense of drama, and importantly, it developed a motive orientation towards design. | The study found that:<ul><li>design concepts can be introduced as part of children's play;</li><li>play amplified design cognition and design processes;</li><li>play narratives create a sense of collective design;</li><li>the drama of the story amplified the need for finding design solutions to the problem that had arisen;</li><li>imagination in design means imagining something that did not yet exist, but it can be realised in a drawing.</li></ul> | Fleer, M. (2021). The genesis of design: Learning about design, learning through design to learning design in play. *International Journal of Technology and Design Education. 32*, 1441–1468. https://doi.org/10.1007/s10798-021-09670-w |

Table 4

*Under the conditions of a Conceptual PlayWorld, teachers change from real relations to play relations, affording new kinds of practices and conditions for children's development*

| Overview | Impact | Reference |
|---|---|---|
| Imagination as a psychological function, resourced teacher development in the motivated conditions of, a Conceptual PlayWorld for practice change | The study found that in the professional development of teachers of a Conceptual PlayWorld, they:<br>• imagined the new practice and solved problems collectively through multiple imaginings of the characteristics of a Conceptual PlayWorld;<br>• imagined "as if" in a mature form of a Conceptual PlayWorld in relation to how children could experience the new practices. | Fleer, M., Fragkiadaki, G. & Rai, P. (2021). Collective imagination as a source of professional practice change: A cultural-historical study of early childhood teacher professional development in the motivated conditions of a Conceptual PlayWorld. *Teaching and Teacher Education, 16.* https://doi.org/10.1016/j.tate.2021.103455 |
| The study found that the problem of increasing early childhood teacher teaching of science appears not to be related to their competence in science discipline knowledge alone, but rather it is about introducing a model designed for play-based settings. In introducing a Conceptual PlayWorld, teachers used theoretical thinking to pedagogically positions STEM in play and to generate authentic problems to be solved. | Four periods of teacher development and theoretical thought emerged over time:<br>• What could be the STEM in the selected book to plan a program around?<br>• What might be the concept to be taught to preschool-age children?<br>• What knowledge is needed to teach the specific concepts?<br>• What is an authentic problem for children to want to solve in their play? | Fleer, M. Fragkiadaki, G. & Rai, P. (2022). The place of theoretical thinking in professional development: Bringing science concepts into play practice. *Learning, Culture and Social Interaction, 32,* 1–15. https://doi.org/10.1016/j.lcsi.2021.100591 |
| A Conceptual PlayWorld as a model of teaching STEM creates motivating conditions for teachers to want to teach STEM in play in preschool settings. | The study found that through participation in the professional development of a Conceptual PlayWorld, teachers:<br>• positively experienced STEM teaching and gained new tools;<br>• gained self-awareness for transforming their STEM teaching practices;<br><br>• increased their motivation, competence and confidence to teach STEM;<br>• devoted more time to STEM experiences;<br>• shifted their professional identity as teachers of STEM. | Stephenson, T., Fleer, M., Fragkiadaki, G. & Rai, P. (2021). Teaching STEM through play: Conditions created by the Conceptual PlayWorld model for early childhood teachers. *Early Years: An International Research Journal.* https://doi.org/10.1080/09575146.2021.2019198 |

Table 5

*Conceptual PlayWorlds create motivating conditions for girls' engagement in STEM in the early years*

| Overview | Impact | Reference |
|---|---|---|
| The study found that rather than a future imagining of engineering by children during free play time, the girls had difficulties with access to the engineering activity setting, and therefore had limited possibilities for acting "as if" they were engineers. | The study found that: <br>• girls were equally motivated to explore engineering, but it was the boys who occupied the spaces and sought to access the resources; <br>• the social enterprise of playing with others with the common goal of engineering a bridge for the "Three Billy Goats Gruff" was evident for all, but the teachers did not bring the girls into the activity or help them to socially negotiate a place within the collective imaginary play of engineering. | Fleer, M. (2021). Future imagining of being and becoming an engineer. *Learning Culture and Social Interaction, 30*(2), 10.1016/j.lcsi.2019.100372. |
| Conceptual PlayWorld changed the traditional Froebelian play areas to support girls' play, competencies, and motives in STEM. | The results show that: <br>• the traditional areas of the preschool were disrupted and new play actions were afforded; <br>• beginning with a story where a social problem arises, was highly motivating for all the preschool children to want to help solve the problem; <br>• teachers were in the imaginary situation with the children and could support girls' initiatives; <br>• rather than girls being excluded, invisible, or not heard, the girls' actions and thinking were constantly validated and affirmed when engaged in STEM play and exploration; <br>• the characteristics of a Conceptual PlayWorld made a difference to girls' access and therefore they heard and saw more technical language and solutions, leading to increased competence in STEM; <br>• girls were positioned as leaders of engineering teams, and their contributions in scientific discussions were valued; | Fleer, M. (2021). Re-imagining play spaces in early childhood education: Supporting girls' motive orientation to STEM in times of COVID-19. *Journal of Early Childhood Research, 19*(1), 3–20. https://doi.org/10.1177/1476718X20969848 |

| Overview | Impact | Reference |
|---|---|---|
|  | • girls' competence grew as they met the demands of the new actions and technical language use, design visualisation, and critical and problem-solving thinking associated with STEM. |  |
| Findings show that teachers' developing consciousness regarding girls' STEM engagement through participation in the professional development of Conceptual PlayWorlds, created a shift in their teaching practices towards becoming more agentic in actively engaging girls with STEM. | The study found that core features supporting girls' engagement with STEM through professional development were:<br>• engaging girls in STEM through drama and a purpose;<br>• increasing consciousness regarding girls in STEM;<br>• orientation that focuses on the inclusion of all children in the STEM activity settings. | Stephenson, T., Fleer, M., Fragkiadaki, G. & Rai, P. (2021). 'You can be whatever you want to be!': Transforming teacher practices to support girls' STEM engagement, *Early Childhood Education Journal*, 1–12. https://doi.org/10.1007/s10643-021-01262-6 |
| The study found that microaggressions towards girls in STEM activities were minimised when teachers were inside the Conceptual PlayWorld | The study found:<br>• a difference in how the teachers interacted with children inside and outside of a Conceptual PlayWorld;<br>• teachers inside the imaginary play situation gave girls increased access to the STEM-related learning areas;<br>• outside of the Conceptual PlayWorld, traditional gendered interactions continued;<br>• when teachers are in character they are closer to the children's narrative, more in tune with occurrences within the play and with each child, allowing them to more closely observe and counteract microaggressions;• Conceptual PlayWorld advanced teachers' critical reflection practices, as they became more aware of gendered interactions and developed a gender lens towards STEM. | Stephenson, T., Fleer, M., & Fragkiadaki, G. (2021). Increasing girls' STEM engagement in early childhood: Conditions created by the Conceptual PlayWorld model. *Research in Science Education*. 1–18. https://doi.org/10.1007/s11165-021-10003-z |
| When teachers and children are in a Conceptual PlayWorld in Indonesia, it was found that the new conditions gave possibilities for a focus child to experience different gender roles. | Three key characteristics of Conceptual PlayWorld related to a child's experiences of gendered roles were identified:<br>• The new model of play and learning foregrounds selecting a character to role play, and this | Utami, A.D., Fleer, M. & Li, L. (2021). An analysis of a child's experiences in playing a gendered character during Playworld, *Learning, Culture and Social Interaction*, 28. https://doi.org/10.1016/j.lcsi.2020.100454 |

| Overview | Impact | Reference |
|---|---|---|
|  | gives opportunities for children to explore different gender roles, disrupting stereotypes.<br>• Teachers as play partners are inside the imaginary play situation and can support a child's motives to explore different gender roles.<br>• Teachers in a role can model new character interactions and disrupt gender stereotypes in the imaginary play. |  |

In studying the effects of a conceptual PlayWorld on children's imagining of concepts, it was identified that because the teachers were inside the imaginary play as play partners, they supported the active imagining of the children and this in turn appeared to support the development of children's play to be collective, and this in turn meant mature forms of play were being enacted and modelled. That is, more complex role-oriented play with complex rules was experienced. Teachers regularly changed the meaning of objects and actions in the imaginary situation to give them a new sense. A Conceptual PlayWorld created new conditions for children's play and development (Fleer, 2021a), which meant that collective imagining in a Conceptual PlayWorld acted as an important precondition for consciously realising the new roles and rules associated with a Conceptual PlayWorld, where curriculum concepts come into the children's play (Fleer, 2021a). But under the conditions of free choice time, where children generated their own Conceptual PlayWorld (Fleer, 2021b), the children on their own could not bring out the scientific conception of the curriculum concepts that the teachers had introduced. Interestingly, the child-initiated Conceptual PlayWorld showed how children do pay close attention to the new practices of teachers introducing STEM concepts into play-based setting. The Conceptual Play-World appeared to create motivating conditions for children during free choice time in preschool, which in further research showed how children became motivated to learn STEM concepts (Fleer, 2021c).

In subsequent research we found that the drama of the play narrative within the collective imaginary play situations amplified the need to find solutions to the problem that had arisen in the story. In that study into the genesis of design thinking, it was found that design problems could be both posed in relation to children's play narrative or arose in child-initiated play. The drama of the story appeared to drive design work. The finding that designing for the children was about imagining something that did not yet exist was important for understanding engineering and design principles in STEM learning. Imagination could be shown in a drawing. The Conceptual Play-World gave a level of authenticity, a sense of drama, and importantly, it developed a motive orientation towards design. Design concepts (plan view, side view, 3-D, 2-D) were introduced as part of the children's play. Play was creating the conditions for giving a purpose to the design work. Play gave possibilities to extend children's designed

solutions, but also to iteratively develop their design ideas. It was found that a Conceptual PlayWorld acted as a source of development of design concepts for preschool children (Fleer, 2021c).

The positive impact of a Conceptual PlayWorld on teacher development also emerged as an important finding to date. Whilst most studies into teacher confidence and competence in STEM teaching focus on what teachers do not know (Gomes & Fleer, 2017; 2018), the Conceptual PlayWorld, acts as a credit model (i.e., builds on teachers' strengths) in designing play-based programs where program goals are oriented to both learning and overall child development. Table 4 brings forward the impact of a Conceptual PlayWorld by drawing out how teachers' conceptions and activities change as they engage in new pedagogical practices of a Conceptual Play-World within their preschools.

During professional development of Conceptual PlayWorld, it was identified that it was not teacher knowledge of STEM that was the impediment to teaching STEM, but rather teachers' pedagogical knowledge of how to bring in STEM concepts into children's play that needed support. Teachers wanted to know how to set up an authentic problem for children to solve within the narrative of the children's play. The study also found that when teachers participated in professional development of a Conceptual PlayWorld, their view of science as a static body of scientific knowledge to be taught was reconceptualised as a new pedagogical practice where the drama of the problem being introduced into the play narrative drove children to want to learn scientific concepts to act in service of their play. This re-orientation was more in keeping with the purpose of play in preschools, whilst at the same time amplifying the play as dramatic and rich with STEM learning possibilities. The new practices and re-orientation afforded through Conceptual PlayWorld enhanced confidence and competence in STEM teaching (Fleer, Fragkiadaki, & Rai, 2022). But it was also learned that the professional development experience not only developed teachers' theoretical thinking, but demanded that they draw upon their own highly developed psychological functions of imagination to collectively imagine the new practices with their peers (Fleer et al., 2022). Professional development of early childhood teachers needs to be more than just knowledge about a new model. It requires teachers to collectively imagine how to bring the new practices into their preschools – acting "as if" in the Conceptual PlayWorld, piloting ideas together. Teacher imagination was found to be core for professional development. Further, teachers' theoretical thinking developed through the process of imagining the new practices and implementing their own Conceptual PlayWorld. Teacher imagination has not been discussed in the PD literature to date.

The programmatic study has shown that a lack of teaching STEM in preschools is not a problem of practice or of teacher knowledge, but rather a problem of having an appropriate teaching model for play-based settings. When different kinds of research questions are asked, different types of findings become evident. Similarly, the age-old problem of the scarcity of girls and women in STEM has also not changed over 20 years. The problem needed to be viewed differently, and new kinds of studies designed and different research questions asked. Table 5 summarises how introducing a Conceptual PlayWorld created motivating conditions to support girls' engage-

ment in STEM. Girls were not excluded from STEM activities in the preschool, but rather through the play inquiries, with their focus on solving social problems through STEM, the girls' actions and thinking were constantly validated and affirmed by the teachers who were present in the imaginary situation with all the children (Fleer, 2021a). The children and the teachers had a common narrative. But the traditional areas, such as the block area and construction areas, which have commonly been dominated more by boys, also changed. It was found that the block area resourced the imaginary play situation in ways that are in keeping with the drama of the story, where the traditional areas and materials took on different roles in children's collective play. Redefining the spaces and the materials changed how children played and interacted in these traditional areas. Because girls had more access and stayed longer in these areas, they developed more technical experience and heard more technical language from the teachers. This positively affected their confidence and competence in STEM. On the other hand, when outside of the Conceptual PlayWorld without their teachers (Stephenson et al., 2021b) or when no Conceptual PlayWorlds was being undertaken (Fleer, 2021b; Stephenson et al., 2021a), girls had limited opportunities and were actively excluded by boys. Conceptual PlayWorlds changed girls' opportunities in STEM (Stephenson et al., 2021). We also found that Conceptual PlayWorlds developed and studied in Indonesia (Utami et al., 2021) opened up opportunities for children to explore different roles. Additionally, teachers in role-play could model different ways of being a character in the story, and for girls and boys to experience non-traditional and non-stereotyped gendered roles during their imaginary play.

Findings are still emerging in relation to methodological and digital innovations (see Fleer, 2014; 2016; 2017b, 2017c; 2018b; 2020b; Fleer et al., 2020; Rai et al., 2020), impact found in international contexts (Li, Fleer, & Yang, 2021; Meng et al., Fleer, Li, & Hammer, 2021; Utami, Fleer, & Li, 2020), and as previous data relevant to the programmatic study continue to be analysed, greater insights emerge over time (Fleer, 2018a; 2018b; 2019a, 2019b; 2020a; 2020b; 2020c).

## Conclusion

We have learned from the programmatic research about the transformative role of a Conceptual PlayWorld for teachers and children for dealing with the central problem of increasing the cognitive load of children. The four areas identified (see Tables 2–5) focus on how a Conceptual PlayWorld changes the conditions of children in group settings, how teacher practices within play-based settings also change, and how these new social situations impact children's social situation of development across cultural age periods, especially in relation to girls' participation in STEM.

The studies show how early forms of imagining begin and the key role teachers play in this process within group settings. It is not just the nature of the concepts for each cultural age period that must be considered and identified, it is also how imagination forms, develops, matures, and becomes imaginary play as the leading activity within the cultural age periods. Conceptual PlayWorlds as a teaching model appears to fit well with supporting the maturing function of imagination, yet this dimension

in STEM education research has not received the attention it deserves. Further research across more diverse settings, and with larger groups of teachers and children, is still needed to be confident of these findings.

The programmatic research also shows the nature of the development of a collectiveness in the infancy and toddler period, where it is seen as a form of togetherness, through to the preschool period where collective play appears to take centre stage. Collective play is a key outcome of Conceptual PlayWorlds because it creates conditions to support a high level of shared understandings, shared imaginings, a common narrative, and common play action. Stories become important in creating a shared narrative, togetherness, and collective play, because in a Conceptual Play-World, teachers and children work with an ideal form (Vygotsky, 1994) of the story, whilst leaving space for children's initiatives and agency in play and in STEM concept formation. Together, the concepts of collective play and the development of shared imagining from infancy have created new developmental understandings. This outcome has emerged through addressing the problem of an increased cognitive load of children and its effect on their development. By considering this problem in relation to the different cultural age periods, we have learned of the central place of imagination and imaginary play, acting as a vortex for metaphorically bringing concepts into children's play in ways that are authentic, meaningful to their everyday lives, and act in service of their play. That is, a Conceptual PlayWorld as an intervention across the cultural age periods positions conceptual learning as taking place during children's play rather than being delivered as isolated learning moments, as has traditionally been conceptualised in the schoolification agenda.

It is through programmatic research that it becomes possible to study the microgenetic development of children, whilst also studying the impact of changing pedagogical practices on teachers' development. Rather than viewing the problem of limited STEM teaching by finding out why early childhood teachers do not teach STEM concepts, the programmatic research asks different kinds of questions. Through drawing on previous foundational research, where conceptual play and the Conceptual Play-World model were the outcomes, this programmatic research was able to more confidently create interventions in professional development for teachers across Australia and internationally. We identified that teachers developed theoretical thinking during the process of their professional development (which included implementation of the intervention in their classroom/centre/family day care). Teachers moved from the problem of identifying a concept and knowledge of STEM, to creating dramatic, imaginary play conditions in which authentic problems emerge which need STEM solutions. Further, the research showed how teachers changed their practices from being outside of imaginary play situations to being a play partner in character within the play. These new conditions not only supported the sense of togetherness of infants and toddlers and collective play of pre-schoolers, but also ensured girls' access to STEM activity, STEM technical language, and the development of a motive for STEM learning. The imaginary Conceptual PlayWorlds disrupted the activity and interactions in the traditional areas within a preschool, such as the block corner. This meant that new ways of playing happened in the preschool, as imaginary situations were resourced through accessing the areas for materials, rather than as ways of tradition-

ally playing. Teachers being inside the imaginary play was shown to be new and challenging. However, in the drama and excitement of the children's play, teachers became motivated towards the new model, the pedagogy, and their changing position from outside of children's play to being inside the imaginary PlayWorlds. In PlayWorlds, teachers amplified, supported, extended, and modelled STEM and play practices, but also followed and enriched the children's own play initiatives. Conceptual PlayWorlds meant that mature forms and rudimentary forms of play co-existed and interacted, supporting the maturation of the children's play. Conceptual PlayWorlds was positively viewed by teachers, because it transformed the institutional practices and the way children entered into, shaped, and were shaped by the maturing play that was being enriched by the STEM actions, thinking, and solutions. Further research into the impact of the intervention of a Conceptual PlayWorld will give more confidence in the preliminary results to date. More research within Australia's culturally and linguistically diverse settings and geographically isolated regions is needed, as is the study of the impact of a Conceptual PlayWorld on children and teachers in different countries. This future research will give further insights into how to support children's development in times of schoolification.

**Limitations**

Indicators of key developmental outcomes are documented in the studies reported, and whilst significant, they cannot yet be generalized beyond the study sample due to the small sampling and specific pandemic context of the research. That is, the programmatic research has not yet achieved the sample sizes it expected due to the global pandemic. Australia has been met with severe institutional access restrictions by the Departments of Education to protect all participants in education, including the researchers.

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