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Parent pedagogical positioning to create conditions for preschooler STEM learning using a Conceptual PlayWorld approach

Sonya Nedovic *, Marilyn Fleer, Prabhat Rai

Monash University, Faculty of Education, Level 3, Building A, Moorooduc Hwy, Frankston, VIC 3199, Australia

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ABSTRACT

STEM education has become a national priority, critical to the future of the workforce and the building of competitive economies across the globe. The literature suggests that early engagement with basic STEM concepts supports mastery of STEM subjects in later school years and in the professions. This has generated a need to better understand the ways children learn STEM concepts in family settings where it is understood that much of children's conceptual development takes place. This paper seeks to examine how parents can pedagogically position themselves to create motivating conditions for STEM learning. Various cultural-historical researchers have theorised that imagination is useful in the development of children's thinking. This paper reports on how an evidence informed model for STEM learning, which uses collective imagination to support conceptual development, when introduced as an intervention into family practice, provided opportunities for a parent to begin positioning themselves with pedagogical impact. Participating families engaged in six Conceptual PlayWorld sessions via zoom with children aged 4 years and 6 months. Through analysis of playful family interactions, the findings show four pedagogical positions or 'interactional themes' initiated by the parent ('above'/'primordial we', 'equal', 'independent' and 'below') each of which created different possibilities for collective imagination and conceptual thinking.

1. Introduction

Recently the Australian Government has acknowledged the important role families play in preschooler STEM learning at home (The Education Council, 2015) and has recognised the connection between the building of STEM capabilities in the early years of life and future national economic productivity (Australian Government Department of Education, Skills and Employment, 2020). The overarching aim of this paper is to examine how families can use pedagogical positioning (Fleer, 2015) to provide motivating conditions for preschooler STEM learning at home. Some cultural-historical researchers have argued that imaginative play is closely associated with STEM learning (e.g. Disney & Li, 2022; Fleer, 2015, 2011, 2017, 2021, 2022; Li, 2022) and that parents are ideally placed to mediate the development of a child's imagination (Hedegaard, 2016). Pedagogical positioning is a concept used to systematically examine the role of adults in relation to children's imaginary play according to the interactional themes of above, primordial we, equal, independent and below (Fleer, 2015). It is for this reason that we frame our discussion about various pedagogical positions and what they afford

* Corresponding author.
E-mail addresses: Sonya.Nedovic@monash.edu (S. Nedovic), Marilyn.Fleer@monash.edu.au (M. Fleer), Prabhat.Rai@monash.edu.au (P. Rai).

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preschooler conceptual development through the lens of imaginary play relations between mother and child.

Whilst studies suggest that parents are "the most direct gateway to STEM learning" (McClure et al., 2017, p.21), there is also an indication that families lack confidence in their STEM related interactions with children (Johnston et al., 2022). Despite this low confidence, the literature continues to trend towards discovering more about existing practices (Salvatierra, Cabello, 2022a, 2022b) rather than introducing new opportunities for conceptual learning into family interactions. Whilst there are some researchers, albeit limited, who have introduced STEM learning opportunities into family interactions (eg. Cronin et al., 2020; Johnston et al., 2022), these interventions have taken place in community settings other than the family home and have focused inquiry on the learning which has resulted as perceived by parents (Salvatierra, Cabello, 2022a, 2022b).

There are limited cultural-historical studies investigating preschooler STEM concept formation in family settings, and the investigation of parent pedagogical positioning is uncharted territory across all early childhood literature. However, pedagogical positioning is an important dynamic to understand when creating a new kind of learning interaction because it informs the adult's effective interactions within the conceptual play space. There is an emerging body of evidence about how kindergarten teachers effectively use pedagogical positioning in formal learning settings to provide conditions for STEM learning. In recent years Disney and Li (2022) have been instrumental in investigating this through the use of the Conceptual PlayWorld (CPW) model (Fleer, 2015). The success of the approach in teaching STEM concepts in preschool classrooms (eg. Fleer, 2017; Li, 2022; Ma et al., 2022) led us to understand that it would also be effective in family settings. In this paper we contribute to filling the gap in understanding effective pedagogical positioning in STEM learning in family settings through the use of a CPW intervention.

Four pedagogical positions (Fleer, 2015) were initiated by the parent with each position affording powerful and specific conditions for development. Our overarching finding is that when parent and child create a collective imaginary scenario and the parent uses pedagogical positioning to place themselves above the child in their introduction of conceptual knowledge, conditions are afforded for rich STEM learning. We also make clear in our discussion that all four positions are dynamic and must be considered in relation to one another.

We begin this paper by charting the pathway to these results by first, reviewing those studies that examine learning and development in family settings, followed by our theoretical understandings where the cultural-historical concepts relevant to our analysis are presented. The study design provides an explanation of the CPW model (Fleer, 2017) and explains how we analysed data in a category scheme (Hedegaard, 2008a). In the findings section we build upon Fleer's (2015) concept of pedagogical positioning to present four themes of interaction between mother and child and the conceptual learning these positions afforded.

2. STEM learning in the home setting

Research in the 'STEM and families' space is primarily undertaken in formal education settings rather than family settings (Brahms & Werner, 2013; Crowley et al., 2011; Hao & Fleer, 2016). Parents report feeling that they require more information about how to facilitate STEM learning (Tippett & Milford, 2017) as they often feel anxious (Dorie et al., 2014) when approaching these interactions. These findings highlight the need for families to be informed about how to approach effective pedagogical positioning in their STEM interactions, so that their practice is evidence based.

Studies also report that parents tend to have narrow understandings of what science is (Larkin & Lowrie, 2022), and often believe that STEM is only for older children, boys, or certain types of children (Dorie et al., 2014). Often, these understandings hinder children's STEM learning (Salvatierra, Cabello, 2022a, 2022b). The CPW model challenges these views by incorporating the introduction of STEM teaching into a play context. Most parents are interested and enthusiastic about preschooler STEM activities (Gilligan et al., 2020) and view STEM learning as being a necessary part of preschooler's development (Salvatierra, Cabello, 2022a, 2022b). The CPW model utilises this enthusiasm to involve the parent in conversations about characters and the entering of an imaginary setting before observing how a STEM problem can then be generated within that collective imaginary space.

The majority of studies investigating STEM learning in family settings are framed from the perspective of identifying children's already existing interactions with environments and material objects and then analysing how children learn in these spaces and contexts (Callanan & Oakes, 1992; Salvatierra, Cabello, 2022a, 2022b). For example, Bell et al. (2009) explains that rich STEM learning environments including beaches, forests and science centres afford opportunities for children and parents to make observations together and engage in ongoing reflective conversations about these observations and experiences. Bell et al. (2009) also finds a correlation between the degree of children's exposure to computers, machinery, tools, and appliances and knowledge about how they function. In contrast, the study reported on in this paper was framed from the perspective of firstly identifying the way the parent pedagogically positioned themselves within their interactions and then analysing how these positions changed to afford different developmental outcomes as the parent became more aware of the evidence informed CPW model.

Research on the role of parents in preschooler STEM 'identity' (how a person perceives their STEM-related abilities) shows that STEM identity originates in the preschool years and is linked to future career choice (Dou et al., 2019). Dou and Cian (2021) report that children who engage in conversation with close family members about STEM from a young age are more likely to grow into adults with a strong degree of STEM identity, and that families are ideally positioned to encourage conversations about science as being culturally relevant and accessible to their children.

It is also believed that everyday conversation is effective in introducing scientific knowledge to children (Callanan & Oakes, 1992; Larkin & Lowrie, 2022), where the role of the parent is to ask and answer questions (Marcus et al., 2017). Callanan and Oakes (1992) report that whilst preschoolers ask questions about scientific phenomena in everyday family situations, the majority of parents' responses do not include reference to complex scientific principles or processes which children are likely capable of understanding. In this paper we discuss how the parent used pedagogical positioning within conversation to introduce conceptual knowledge relevant to

family culture. We also detail evidence of the child's understanding of this new conceptual knowledge as demonstrated in imaginary play.

It is well understood within cultural-historical theory that learning is socially mediated and that when children and adults engage in conversations about their experiences, new understandings are constructed (Vygotsky, 1987a). Adult-child conversation plays a large role in the CPW approach where scientific concepts are discussed within an imaginary play scenario (Fleer, 2017).

A multitude of studies also report on the formation of preschooler STEM-related interests (Johnson et al., 2004; Pattison et al., 2022). Interest-led programs are derived from a traditional view of development, defined as occurring biologically and following a linear pathway through predetermined stages on a developmental continuum (Gibbons, 2007). For this reason, interest-led programs, where the goal is to keep development 'on track', dismiss the pedagogical role of the adult within imaginary play. This is in contrast to cultural historical research which has found intentional teaching practices to be crucial for conceptual development (Lewis et al., 2019). In a CPW approach, the focus is not on discovering what children's interests are and then providing opportunities for these interests to develop. In contrast, this approach encourages adults to take an active role in imaginary play themes and intentionally teach concepts which challenge children's thinking (Fleer, 2009, 2015). Through focusing our attention on how parents can dynamically position themselves to do this, we can better understand the relationship between these pedagogical positions and how they afford conceptual development.

Finally, we shift our attention to the literature about STEM learning in studies involving interventions. Cronin et al. (2020) reports engagement in children's museum programs as having capacity to develop critical learning skills, support parents to engage their children in STEM-related conversation and create enthusiasm for solving problems as a family. A paper discussing an intervention in an aquarium setting has reported that often-overlooked types of parent conversation can lead to opportunities to learn about science together (Ocular et al., 2022). Further to this, Makerspace programs in museums and libraries have been found to encourage broad community participation, support families and adults as co-learners, challenge inequity in opportunity and intergenerational aversion towards STEM learning (Johnston et al., 2022) and support collaborations (Dittert et al., 2021; Jones et al., 2019). In discussing these programs, Marcus et al. (2017) explains that for informal community settings to generate meaningful learning outcomes, they must provide families with resources to support children's transfer of knowledge to the home setting. Through generating knowledge about parent pedagogical positioning in STEM learning in home settings, parents are provided with teaching skills which are transferable across a multitude of settings.

3. Theoretical foundations of the study

To answer our research question, which is to examine how parents can pedagogically position themselves to create motivating conditions for STEM learning, we have used the concept of 'pedagogical positioning' (Fleer, 2015). Historically, this concept has only ever been used in literature to discuss the findings of studies undertaken in formal learning institutions rather than family settings. However, the vast majority of these studies have also used a cultural historical methodology with data generated through the CPW model (eg. Disney & Li, 2022; Fleer, 2015). Given the backdrop, this concept serves as a powerful tool in examining the dynamic interplay of parent and child interactions because it provides us with a context of how these positions have been effectively used to afford STEM learning in settings prior to our study. Within this discussion, we have examined the theme of 'imagination and concept formation' (Fleer, 2011; Vygotsky, 2004). This theory assists us in understanding how a parent's specific pedagogical positioning affords STEM learning because pedagogical positioning occurs within the context of imaginary play scenarios shared between parent and child. In these CPW scenarios, imagination and concept formation are viewed as being interwoven and inseparable (Fleer, 2017). These concepts are discussed in turn.

3.1. Pedagogical positioning

In the process of thematic interpretation where we examined how the mother positioned herself in relation to the child from the perspective of imagination and concept formation, Fleer's (2015) concept of pedagogical positioning became visible to us. This model identifies 4 interactive moments categorising the way an adult interacts in a child's imaginary play (Table 1). We could see that in the family context, all imaginary and conceptual interactions between mother and child could be categorised as belonging to one of these 4 types of interaction. However, whilst the four categories of pedagogical positioning may be relevant to both kindergarten and home environments, the ways these themes transfer across institutional settings and how these interactions afford conceptual development, is uncharted territory. When a teacher in a kindergarten positions themselves within a pedagogical theme of interaction, each child's

Table 1
Fleer's (2015) pedagogical positioning model specifying 4 interactive moments which categorise the way an adult interacts in a child's play.

1.	Above Primordial We	The teacher models and explains content knowledge. The teacher takes lead in play with the purpose of developing the child's ability to understand and contribute to play themes. The child is swept away in the play but does not necessarily understand key narrative ideas or concepts.
2.	Equal	Teacher and child work together to arrange play themes.
3.	Independent	The teacher positions themselves outside the child's play and the child works capably, engaging in 'social referencing' where they glance back at the teacher to see if they are observing.
4.	Below	The teacher's role is to provide space for the child to take initiative or solve problems, e.g. asking questions as though the child is an authority.

positioning can also be analysed in relation to every other child with whom they are interacting. However, in the family reported on in this paper, the child does not have a sibling at home during the day, therefore when the parent positions themselves pedagogically, this practice has a powerful influence on the conditions provided for the development of imaginary play and conceptual development.

Fleer's (2015) pedagogical positioning model formed the findings of a study which examined children and teacher interactions during free play time in childcare settings. The model describes how, when children create their own play, their teachers shift into pedagogical positions which can be categorised into five distinct yet dynamic groups. The study reported on in this paper is different because our process of analysis began with the parent. Rather than observing the activities of the child and then examining how the adult participated in this interaction, we focused our analysis on observing the imaginary and conceptual activities initiated by the parent as a result of the CPW intervention. From here, we sought to answer our research question which asked how parent pedagogical positioning affords STEM learning in family settings. To do this, we analysed how the child responded to each of these pedagogical positions and then, after analysing these responses using our category scheme for situated practice interpretation (Refer to Table 3), we built upon Fleer's (2015) model to include a column identifying the way each pedagogical position afforded opportunities for the development of imagination and/or STEM learning.

3.2. Imagination and concept formation

Contradictory definitions of imaginary play and resulting developmental affordances exist among both early childhood scholars and practitioners (Shlomo, 2002). To ensure understanding of imagination from a cultural-historical standpoint, it is necessary to define this concept in the words of Vygotsky. Vygotsky (2004) explained that all human behavior and activity can be categorised into two basic activity types; reproductive and combinatorial (or creative activity). Reproductive activity occurs when a person reproduces

Table 2
Methods and data.

Method of data collection.	Type of data generated
'Part A' of the 'Parent pre-study questionnaire' asked Kira to describe the various play activities Paige participates in at home. Whilst the questionnaire reminded Kira that the study was about STEM, it did not ask about Paige's participation in STEM-specific play activities.	Kira provided a list of the 'types' of play Paige engages in on a frequent basis (eg. playing independently with toys, pretend play with dolls, drawing and building forts). Kira also provided information about her role within this play, which we linked to Fleer's (2015) Pedagogical Positioning model. This data contributes to our understanding of family play interactions as they occurred before the CPW intervention.
'Part B' of the 'Parent pre-study questionnaire' asked Kira to explain the family's perspectives about play, their understandings of play, and what matters most to them in relation to Paige's development.	Kira described the kinds of learning Nathan and herself hope Paige will achieve through her play (eg. life skills), and how they position themselves in relation to play interactions and family activities to facilitate this development. This data contributes to our understanding of the reasons why Kira positioned herself in particular ways in the pre-intervention home play scenarios which she captured and sent to the researcher (e.g. 5.1.2. para 3).
Family videos and photographs sent to the researcher. Kira provided the researcher with 5 videos and 2 photographs capturing Paige engaging in imaginative play in the family setting.	This data depicts Kira and Paige's typical play interactions both before the CPW intervention and after the family had participated in several CPW sessions (eg. Fig. 1 below). Shifts in parent pedagogical positioning across these videos were analysed in relation to the influence of the CPW intervention (see Findings and Discussion).
Conceptual PlayWorld Intervention zoom recordings.	This recorded data captured the gradual shifts in imaginary and conceptual play interactions between Kira and Paige which occurred in the context of the CPW intervention. These interactions were categorised using Fleer's (2015) pedagogical positioning model. This data also led us to identify and foreground new pedagogical positions (see Findings and Discussion).
Conversations between the researcher, Kira and Paige which occurred within Zoom but outside the CPW. These conversations were facilitated by the researcher with the purpose of better understanding the context of some of Paige and Kira's specific contributions to the CPW imaginary scenario.	The researcher asked questions about some of the specific ideas which Paige and Kira had contributed to the imaginary play narrative. Paige and Kira provided information about where these ideas came from, which enabled the researcher to understand how the everyday family environment influenced imaginative and conceptual play within the CPW (e.g. 5.1.2. para 3).
Emails between the parent and researcher. The researcher emailed Kira weekly to provide detailed information about the 5 characteristics of the CPW model and how these characteristics would be implemented in our next CPW session. Kira was provided with a recording of the researcher reading Sheep in a Jeep which she could play to Paige between sessions and a YouTube video explaining the concepts of motion and force in everyday plain language.	Through reading this email correspondence, Kira was able to develop her understanding of the CPW approach and the role of imaginative and conceptual play in STEM learning. This knowledge supported her to intentionally step into new pedagogical positions during CPW zoom recordings. Kira also used email correspondence to keep the researcher updated about family events which related to themes in Paige's play (eg. 5.1.3. vignette 2). This enabled the researcher to better understand how the family's practice traditions, values and beliefs influenced Paige's imaginary play.
Parent post-study zoom interview where Kira was asked to provide her perspective in response to the following 4 questions. 1) What worked well in relation to Paige's STEM learning in the study? 2) Which aspects of the study were the most challenging? 3) What do you feel were the STEM learning moments or learning shifts? 4) What do you feel were the key STEM moments in the study?	Kira explained that the study changed her understanding about the role of imagination in STEM learning and the quality of STEM learning which can be achieved through carefully planned collective imaginary play. Kira used examples of Paige's interactions within the CPW to illustrate this thinking. This data contributes to our understanding of family STEM interactions by helping us understand Kira's shifting perspective about conceptual learning and the process of how this motivated her to engage with new pedagogical positioning (e.g. 5.2.2, Vignette 5).

or repeats familiar behaviours, follows a specific model, reproduces what exists in front of them, or when they recover traces of earlier impressions or stimulation formed through life experiences.

According to Vygotsky (1987b), reproductive activity alone is not enough for new conceptual understanding to develop. "No accurate cognition of reality is possible without a certain element of imagination, a certain flight from the immediate, concrete, solitary impressions in which this reality is presented" (Vygotsky, 1987b, p.349). Vygotsky (2004) stressed that contrary to popular belief, combinatorial activity or 'imagination' is not a rare skill existing only in particular types of people. Rather, it is a necessary and fundamental cognitive function used by most children and adults throughout their daily lives. During the process of combinatorial activity or 'imagination', the brain "combines and creatively reworks elements of past experience and uses them to generate new propositions and new behavior" (Vygotsky, 2004 p. 9). This is essential to human existence because "absolutely everything around us that was created by the hand of man, the entire world of human culture, … is the product of human imagination and of creation based on this imagination" (Vygotsky, 2004 p. 9–10).

The inseparability of conceptual learning and imagination as perceived by the cultural-historical theory of child development means that, for us to understand how parents can position themselves to support STEM learning, we must include the concept of imagination in this investigation. What we also understand about adult interactions in children's imaginary play, is that when adults model and present higher forms of play practice, children's play also becomes more complex (Lindqvist, 1996; Hakkarainen, Bredikyte, Jakkula and Munter, 2013). Our study design utilises the CPW model to better understand parent pedagogical positioning in imaginary play and STEM learning because research has consistently reported that the approach is effective in encouraging adults to engage in collective imaginary play with children (Li, 2022; Stephenson et al., 2023; Utami et al., 2023).

According to cultural-historical theory, another way adults support children's developing imagination is by providing conditions which enrich early life experiences. Vygotsky (2004, p. 14-15) describes the most important law governing the operation of imagination as being that "imagination depends directly on the richness and variety of a person's previous experience because this experience provides the material from which the products of fantasy are constructed." In the present paper, we identify impressions used by the child to furnish their imaginary play situations. We seek to examine the role parents played in the formation of these impressions so that we can gain a perspective about how parent pedagogical positioning within everyday family interactions afford the future development of rich imaginary play themes and/or STEM learning. As detailed in Table 2, our study design enabled us to do this through the inclusion of a multimethod approach. Questions asked by the researcher throughout these data collections were aimed towards understanding not only where the child's observed play themes and contributions originated from, but also the pedagogical position taken by the parent at the time these impressions were formed.

Our multimethod study design provided us with a rich and holistic data set reflecting parent attitudes and beliefs about imaginary play and conceptual learning together with parent pedagogical positioning practices across a broad range of contexts. As data was collected over a six month period, we were able to identify shifts in parent perspectives throughout the introduction of the CPW model. To assist us in arranging this raw data, we developed a category scheme (Hedegaard, 2008a) which functioned as a framework enabling a dialectic between the aim of the research, the theoretical preconditions and the concrete material (see Table 3). eg. Category 3 of the framework is about the patterns of interaction which happen between mother and child, and include collective imaginary play between mother and child and collective conceptual thinking between mother and child. All data snippets from the study which related to imagination and/or conceptual thinking were tagged with a number from 1 to 5 depending on the category it reflected. This enabled us to identify different types of imaginary and conceptual interactions in the family setting and the ways these interactions afforded STEM learning.

Table 3
Category scheme for situated practice interpretation where theoretical themes relevant to this paper and the research question are labeled 1–5.

1. Motives of Paige

- Imaginary play motive
- Conceptual thinking motive

2. Motives of Kira

- Imaginary play motive
- Conceptual thinking motive

3. Interactions between Paige and Kira

- Collective imaginary play
- Collective conceptual thinking

4. Competence of Paige and Kira

- Kira's creation of conditions for imagination or conceptual thinking
- Paige's developing imaginary play and conceptual thinking

5. Conflicts between different intentions and the activities

- Practices limiting collective imaginary play
- Practices limiting conceptual engagement

4. Study design

4.1. Research question

This study sought to examine how families can position themselves pedagogically to provide motivating conditions for preschooler STEM learning at home.

4.2. Site and participants

The family reside in a suburb south-east of Melbourne's central business district in Victoria, Australia. Their city council is ranked in the 45th percentile of socio-economic status of Australia's suburbs and localities (Australian Bureau of Statistics, 2016), indicating that approximately 45 % of Australia's suburbs have a socio-economic index lower than this area and 55 % higher. The family identify their cultural and ethnic background as being Australian and members include mother (Kira), father (Nathan), and two siblings (Paige, 4 years and 6 months and Dylan, 7 years 4 months). Pseudonyms have been used throughout. Kira self-selected to be involved in this research after receiving information about the study from Paige's child care centre. The CPW data collection sessions took place over zoom, with the family located at home, due to COVID-19 related social distancing measures.

4.3. Defining the use of an intervention in the form of a CPW

Beginning with the work of Vygotsky, interventions in family settings have a long history in cultural-historical research (e.g. Luria, 1976; Luria & Yudovich, 1959). Changes are made within the theoretical system of an educational process, and a new form of teaching is introduced with the goal of creating optimal conditions for children's learning and development (Hedegaard, 2008b). In the present study, first, Kira's positioning in relation to Paige's play, imagination and conceptual development were analysed. Then, the researcher introduced a new teaching practice which took the form of a CPW. After Kira became familiar with the approach, she made the decision to incorporate the teaching principles into her own interactions with Paige. Analysis of data reflecting this new STEM interaction focused on relations between Kira's implementation of new teaching practice and Paige's responses to this, including how it steered motive development and how it afforded learning and development (Hedegaard, 2008b).

Hedegaard (2008c) also outlines that in cultural-historical research, participants should be in control of how much they want to tell the researcher and how much they want the researcher to observe their activities. Kira held her smartphone in her hand to connect to zoom, which was the primary mode of data collection. This enabled her to control the video and audio data which was collected in the sessions. Another important consideration is for parents not to feel that the researcher is taking over their own roles or responsibilities (Hedegaard, 2008c). Kira expressed wanting to be involved in the research because of a desire to learn more about how to support Paige's STEM learning. The researcher explained that her participation in the teaching practices of the CPW was optional, and Kira chose to change her pedagogical positioning throughout the study when she noticed Paige's enthusiasm in the study (post-study interview).

4.4. Design of the CPW intervention

A series of 6 CPW interventions (Fleer, 2017) spread over a 6 week time period were implemented, and the play themes in these sessions were developed by the researcher in collaboration with Kira and Paige.

For example, Kira and Paige independently created the jeep which Paige sat inside during the sessions (see Fig. 1.), between sessions they together selected props which were then used by the researcher to help develop the narrative (eg. baby doll), and

Fig. 1. Photographs of the sheeps' jeep created by the family between CPW sessions.

information provided by Kira in relation to Paige's interests and family life was utilised by the researcher to support Paige in solving STEM problems (see 5.2.2 Vignette 4). The researcher recorded CPW sessions through the zoom record function. Kira reported that Paige was excited by the prospect of participating in all 6 zoom sessions, that she enjoyed the attention, and that she found the zoom nature of the study to be fun and engaging (post-study interview). Kira stated that zoom sessions were easy for her to manage and that use of the platform did not affect her experience of understanding the CPW approach or in Paige's ability to connect with the researcher or engagement in imaginary play. A total of 5 h of data capturing the CPW intervention together with parent discussions was collected. Kira remained with Paige for the duration of all recordings. Data reported on in this paper was part of a study where 19.5 h of data shared between four family settings within close proximity of one another was collected. Kira was competent in her use of zoom technology, which meant that she was not distracted or preoccupied by any technological issues during the data collection sessions. Kira's skilled use of the screen orientation function on her smartphone ensured that all of Paige's activities and interactions were adequately captured as she moved around the house in play.

Characteristics of a CPW include:

1) Use of a dramatic story with a complex and engaging plot, excitement and dramatic tension which lend itself to a problem situation needing to be solved. The researcher selected Sheep in a Jeep because it fit this criteria.
2) Design of an imaginary space. Paige and Kira created a jeep to sit inside.
3) Entering and exiting the CPW. Cultural devices signalling entry/exit were song, change of zoom virtual background, and sheep ear headbands.
4) The introduction of a problem scenario linking to the concept being explored.The problem scenario involved finding a way to stop the jeep from rolling down the hill so that animals would remain safe.
5) Considering the role of the adults. The researcher became a character and play partner and invited Kira to do the same.

4.5. Data generating approach

A qualitative multimethod approach was taken to data collection. The objective was to better understand the family's practice traditions, values and beliefs in relation to imagination, play and STEM learning, and how these findings sit within Fleer's (2015) subject positioning model. In our analysis (see 4.5. for a description of this process) we were able to use theoretical concepts (see 3.1. and 3.2. for a description of these concepts) to analyse how, as a result of the CPW intervention, the family's pedagogical positioning changed and how these new dynamics provided enriched opportunities for STEM learning. This enabled us to answer our research question, being to examine how parents can pedagogically position themselves to create motivating conditions for STEM learning.

The methods used in this study and the types of data they generated are outlined in Table 2 below.

4.6. Analysis

Hedegaard's (2008a) three forms of interpretation are used to identify theoretical concepts in data. These concepts form a framework enabling the researcher to understand how parent positioning affords opportunities for collective imaginary play and conceptual thinking.

In the *common sense interpretation* phase, data is replayed and then translated into a series of short time stamped statements which explicitly describe the interaction. *Situated practice interpretation* involves identifying each interpretive comment as belonging to a specific activity setting or multiple activity settings. The intention is not to identify exact events but rather meaningful correlations between interpretive comments. In our *thematic level* interpretation we label situated practice interpretations from 1 to 5 according to the cultural-historical concepts they link to (see Table 3 below). In the process we find patterns directly connected to the aim of the research.

5. Findings and discussion

We seek to understand how parents can pedagogically position themselves to create motivating conditions for STEM learning. This objective is better understood when we consider that, from a cultural historical perspective, imagination and conceptual development are interrelated (Vygotsky, 1998), and imagination is a construct formed through collective social activity (Vygotsky, 1987b). Given this, we begin our discussion by presenting our first overarching finding, which explains how Kira began to use the concept of pedagogical positioning to provide conditions for Paige's imagination to develop (5.1). We will present three vignettes, each of which illustrate specific pedagogical positions taken by the parent during free play time in the family home and during the CPW intervention. We discuss how these powerful pedagogical positions afford the development of rich imaginary play themes, and in doing so, we also discover that imaginary play alone, regardless of its complexity, is not enough to provide the conditions for STEM learning.

Following on from this, we present our second overarching finding (5.2.1) which directly answers our research question by focusing on how Kira used the concept of pedagogical positioning within an imaginary play scenario to provide conditions for Paige's STEM learning. In this second overarching finding we become familiar with two vignettes showing how Kira positions herself above Paige to introduce conceptual information within the imaginary scenario and then below Paige to question her understanding of this information. In the theoretical discussion which surrounds these vignettes, we show that when Kira as the parent dynamically positions herself above and below Paige within a conceptual play scenario, motivating conditions for STEM learning are created. All vignette examples, findings and discussions are presented in chronological order reflecting their placement in the study. This enables us to

illustrate the relationship between the family's involvement in the CPW and how this influenced the development of collective imagination, the maternal introduction of conceptual knowledge to this play and collective conceptual thinking.

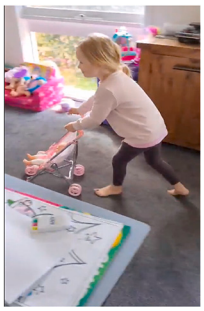
5.1. Collective imagination in the family setting

5.1.1. Independent positioning

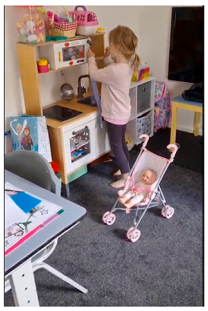
Our findings indicate that when Kira used independent pedagogical positioning, which was the practice tradition in the family home at the commencement of the study, Paige created her own imaginary play. Whilst this play was of rich imaginary form, it did not provide immediate conditions for STEM learning. Vignette 1 (below) provides an example of Kira's independent pedagogical positioning. In this example we notice that, whilst Paige frequently glances towards Kira, Kira does not communicate verbally with Paige and her physical positioning is several meters from Paige. Her role is to allow Paige time and space to play using the props she has provided prior to the commencement of the interaction. We also notice that Paige competently brings creative ideas into the play scenario, independently developing a complex narrative of imaginary events.

Vignette 1.

Paige accesses Google maps by tapping the palm of her hand.



Paige turns to travel in the other direction.



Paige cooks a meal for her baby and comments that it is too hot.

Paige pushes her pram, pretending that she is leaving home to walk her baby to the park. On the way, she stops to access Google maps by tapping the palm of her hand. This App tells her that it is about to rain, so she turns in her tracks and walks back home. Upon returning home, Paige begins cooking dinner for her baby. She frequently glances at Kira who is filming the play and then resumes her activity. She places food into the blender which she holds firmly against the bench whilst it wizzes around, blending the food. She places the meal into a bowl and then into the microwave. Once the microwave beeps, Paige stirs the food and comments that it is not hot enough before returning it to the microwave and pressing various buttons to facilitate further cooking time. Throughout this interaction, Kira is positioned independently of Paige and does not provide any communication or input.

Vignette 1 reflects Kira's belief upon entering the study, which is that in play, children should interact "how they wish to without input from a parent", and that when adults engage in imaginary play, learning and creative thinking is disrupted (pre-study questionnaire). Family recordings such as Vignette 1 capture unstructured and unguided play where Paige takes the lead and Kira is an observer, positioned outside Paige's play without any conversation. In Vignette 1, Paige frequently looks towards Kira and then resumes her play activity. Paige's engagement in this social referencing is not surprising to us given Fleer's (2015) discovery that when a teacher assumes independent positioning, the child regularly looks back to them for confirmation or to see if they are present and observing. In this position, Kira is not *actively* supporting play pedagogy, however we argue that her historical practice within Paige's concrete social world provides the rich conditions required for Paige to create imaginary situations like this. Vygotsky (2004) explains that whilst a single person may present a new creative idea, this activity is always a product of collectives, with aspects of the idea drawn from 'needs' and 'inventions' produced by others before them. For example, we are aware from our other conversations with Kira that Paige frequently participates in using a smartphone to access the weather App so that as a family they can discover what the weather will be like for the day. As Vygotsky explains, they do this because of their 'need' to know what the weather will be like so that they can plan their day, and this is made possible because of the 'invention' of the weather app. In Vignette 1, we see Paige re-enact this process in her imaginary play. She places her finger against her hand as though pressing the screen of a smartphone and then pretends that it is about to rain. She responds to this by quickly returning home with her baby. Another example of collective imagination is seen in Vignette 1 when Paige demonstrates a high level of conceptual understanding in her use of kitchen equipment (microwave and blender). Paige removes food from the microwave when it beeps, stirs it, and after finding it is not hot enough, returns it to the microwave for more cooking time. Once it is adequately warmed, she places it into the blender so it is smooth enough for her baby. She ensures that she holds the blender firmly in place on the bench as the blade rotates so that it does not slide off the surface as it spins. This imagination is collective because these processes have been experienced by Paige in her historical interactions with her parents, who believe that the development of life skills is central to learning, and include Paige in all aspects of family life including the cooking of all meals and use of household appliances (pre-study questionnaire).

Vygotsky (2004) argues that "the more a child sees, hears, and experiences, the more he knows and assimilates, the more elements

of reality he will have in his experience, and the more productive will be the operation of his imagination". Paige's competence in understanding the process of heating and blending puree, pressing microwave buttons to adjust the temperature of food and using the weather App show us how Paige's parents have created an educational setting where Paige has seen, heard and experienced vast elements of reality. We use Vygotsky's argument to illustrate how Paige has used this assimilation of experience within her imaginary play and argue that this has enabled the play to develop into a rich form.

5.1.2. Equal positioning

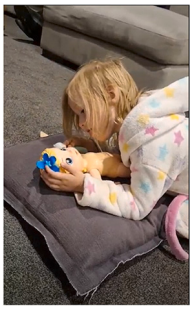
As the study progressed, we began to notice a shift in the way Kira positioned herself pedagogically during free play time at home (family recordings sent to the researcher). In this new equal positioning, Kira began to verbally acknowledge Paige's ideas whilst Paige played. In Vignette 2 which follows, we see an example of this type of interaction. Here we notice that, in contrast to independent positioning, Kira is now positioned physically close to Paige. She shows Paige that she is watching and listening to the play by initiating a conversation where she asks a series of questions about the imaginary context. We notice that in response to this, Paige's interactions are also different to what they had been when her mother was in an independent position. In this new type of play positioning initiated by Kira, Paige's focus shifts from being inside her own play whilst checking to see if Kira is observing her, to being both inside her play and parallel to her own play as she explains to her mother what is happening in the imaginary scenario.

Vignette 2.

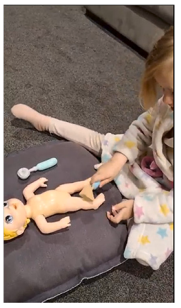
Paige positions her baby on a soft cushion and uses a medical tool against their knee to perform a procedure. Kira sits close to Paige who speaks to the baby in a soft, reassuring voice and to Kira in a louder tone. This interaction occurs during COVID-19 lockdown where Paige and her family are quarantined in their home and in light of this, have experienced medical interventions and engaged in discussions about the role of doctors (data obtained from email correspondence with Kira).

Kira	*What are you doing, doctor?*
Paige	*I need to fix her*
Kira	*Is she okay?*
Paige	*No*
Kira	*What's wrong with her?*
Paige	*She's sick*
Kira	*Oh. How are you going to fix her?*
Paige	*I have to broke her*
Kira	*You have to what?*
Paige	*Broke her*
Kira	*Oh, okay*
Paige	*And then fix her back together*

Paige looks at Kira to answer the questions about her role as a doctor, fixing her baby.



Paige places a thermometer into the baby's ear.



Paige uses a reflex hammer to tap the baby's knees one by one and then pull their feet saying "Pop".

Equal positioning is similar to independent positioning because in both interactional themes, Kira positions herself to provide Paige the space to create imaginary situations without her guidance. However, when in an equal position, Kira engages Paige in verbal communication, asking questions about the play. Examples of these questions include (Vignette 2) "What are you doing doctor?" and "Is she okay?" When Kira asks these questions, Paige no-longer engages in the social referencing behaviours identified in Interactional Theme 1. Instead, she describes the imaginary narrative she is developing, for example, "I have to broke her …. and then fix her back together". From a theoretical perspective, during independent positioning, Paige remains enmeshed 'inside' the imaginary situation (Kravtsov & Kravtsova, 2010). Whilst she glances at Kira on multiple occasions, she does not step outside her play to view it from another perspective. In theme 2, when Kira asks Paige to explain aspects of her imaginary narrative, conditions are provided for Paige to step 'outside' the play (Kravtsov & Kravtsova, 2010) and see the content and evolving plot from another perspective, eg. Kira asks "What are you doing, doctor?" to which Paige looks away from the baby, changes her tone of voice and explains "I need to fix her …. She's sick". Kravtsov and Kravtsova (2010 p.14) tells us that when a child is able to be both inside and outside their play, looking at their imagination "from the side", they can develop and control the plot. This affords the development of imaginary play. These

independent and equal positions, when initiated by Kira, both provide specific affordances for the development of Paige's imaginative play. However, what we are yet to see as a result of these pedagogical positions, is Paige engaging in conceptual play and developing her STEM understandings. As the study progressed and Kira shifted to an above position, introducing new imaginary ideas and conceptual knowledge, we are able to identify new conditions fruitful for conceptual development.

5.1.3. Above position within the imaginary narrative

During the third of six CPW sessions, Kira made the decision to become a character within the imaginary narrative, and in the role of a sheep, contributed new imaginary ideas to the play scenario. In her contribution of these new ideas, Kira positioned herself above Paige. In Vignette 3 which follows, we notice Kira's above positioning through the way that she gives Paige some important jobs to do on the farm and implies that these tasks require urgency. We also notice that in response to this above positioning, Paige follows along with Kira's ideas. Another aspect of this vignette which we pay particular attention to, is half way through the interaction (marked in the vignette) when Kira shifts to equal positioning. We notice that, by shifting to equal positioning after introducing a new imaginary idea, space is provided for Paige to build upon this idea. It is during the dynamic complexity of this interaction that we see collective imagination unfold to its richest form in the family setting.

Vignette 3.

The researcher suggests play partners drive the jeep back to the gate. Kira uses a sheep voice e.g. *she says "Baa Baa" intermittently and places her hands on either side of her forehead to indicate sheep ears.*

Kira	*(In a sheep voice) Quick, we've got to get back to the gate before all the animals escape the farm …. Quick, hop in!*
Paige	*Go! Go!*
Paige races to the jeep and sits down. She rapidly turns her steering wheel.	
Kira	*Quick drive drive drive!*
Paige	*Let's go faaast!*
Kira	*Not too fast, better be safe!*

Play partners return to the gate and Kira shifts to equal positioning.

Paige:	*The animals have escaped!*
Kira:	*Have they?*
Paige:	*I want to pretend that they have.*
	Paige searches the playroom for lost animals and guides them back through an imaginary farm gate. Kira is now in an equal position, no longer contributing to the play narrative but asking questions and making statements.
Kira:	*Good job!*
	Are the (animals) back now?
	Alright, I think we're about to finish up Paige.

Vignette 3 highlights the dynamic nature of interactional themes. To begin, Kira takes an above position where she directs the narrative towards sheep returning to the farm gate by explaining "Quick, we've got to get back to the gate before all the animals escape the farm". Upon arriving at the gate however, Kira swiftly shifts to an equal position where she provides space for Paige to appropriate this idea into the collective imaginary play. It is at this time when Paige builds on Kira's narrative by stating "The animals have escaped!" and Kira asserts her equal positioning by stating "Have they?" which allows Paige the opportunity to play out the idea of the animals escaping the farm by searching her playroom for lost animals and guiding them back through an imaginary farm gate whilst Kira asks questions and makes statements (eg. "Good job!") characteristic of an adult's role in equal positioning.

The importance of fluid pedagogical positioning (Fleer, 2015) is also highlighted by Disney and Li (2022) in their work creating a

Table 4
Summary of parental development of a collective imaginary situation.

Pedagogical Position	Parent perspective	Developmental affordance (Imagination)
1. Independent.	Parent is on the outside of the child's imaginary play. Interaction comes in the form of providing props and allowing time and space to play.	Imaginary play occurs with the child creating their own activities. As the child draws from life experiences to create a play scenario, this dramatisation is a product of collectives.
2. Equal	Parent verbally acknowledges the child's ideas but does not build upon them. Encouragement is provided and the parent may join in with the already existing play themes, anecdotally comment on what the child is doing or ask questions about the play.	
3. Above position within the imaginary scenario.	The parent engages in imaginary play with the child and brings new imaginary ideas to the play scenario.	Imaginary play develops into a complex and exciting narrative.

mathematical CPW in a formal preschool setting. For example, when teachers observe play they are able to step back and "build their understanding of the children's intention, initiation, and exploration of (a) dramatized conceptual problem" (Disney & Li, para. 35). With this knowledge, the teacher is then equipped with the understanding and context to effectively shift to a position where they explore the problem together with the children in a way which is meaningful to the children in that particular play scenario. This finding indicates a synergy between the affordances of dynamic pedagogical positioning across institutional settings.

5.1.4. Table 4

Table 4 below summarises the findings we have discussed so far, which relate to how Kira used pedagogical positioning to develop a collective imaginary situation. Column 1 states the pedagogical position used by Kira with reference to Fleer's (2015) pedagogical positioning model. Column 2 reports on Kira's activities when she positions herself within these specific interactional themes. Column 3 outlines the developmental opportunities for imaginary play afforded through each pedagogical position.

5.1.5. The emergence of collective conceptual thinking for the development of conditions for STEM learning

So far we have discussed how, as the CPW intervention unfolded, Kira used particular pedagogical positions to afford the development of Paige's imagination in play. However, what we are yet to do at this point in our paper is directly answer our research question by reporting on how Kira used pedagogical positioning to provide conditions for Paige's STEM learning to develop. In answering this question, we frame our argument from the cultural-historical perspective that imagination is strongly associated with conceptual learning (Vygotsky, 2004) and stress that the interactions discussed in our above findings provide the context for the STEM learning reported on below in 5.2.2 and 5.2.3.

5.1.6. Above position within the solving of the STEM problem

In 5.1.4 we reported that when Kira assumed the above position within the imaginary narrative, this afforded opportunities for Paige's imaginary play to develop, but not necessarily her STEM learning. We now go on to report that, when Kira assumed an above position within the solving of the STEM problem nestled within the imaginary narrative of the CPW, STEM learning was afforded. This new type of interaction involving both collective imagination and conceptual discussion was initiated by Kira when she noticed that Paige was invested in solving problems presented in the CPW sessions. Kira explained "I wanted to do what I could to help her solve the problems because she loved the play so much and was getting a lot out of it" (post study interview). In Vignette 4 below, we pay close attention to the way Kira's interactions provide a direct contribution to the STEM problem, and how this differs in complexity from the contributions she made in building the imaginary narrative above where she merely suggested that the animals may escape the farm unless the sheep hurry back to the gate. We also notice that Paige's response demonstrates conceptual play and STEM learning.

Vignette 4.

The researcher asks how the jeep could be slowed in its roll down the hill.

Kira	*When I'm driving, do you know what I use Paige? I use a break. I put my foot on my brake and it slows down my car and then we can get to a stop, you know when I turn corners and things there's another pedal? That's a brake. Or, you know what daddy does when he doesn't want his trailer to move? He puts a rock under the wheel and then the trailer doesn't roll anywhere.*
Moments later, Paige places rocks (Kira's shoes) in front of the wheels of the jeep. Paige then corrects herself, explaining that the rocks need to go behind the wheels of the jeep, as the jeep is rolling backwards not forwards.	

Our finding is that when the parent enters the child's imaginary play and then pedagogically position themselves above the child to contribute to the solving of the STEM problem, conditions are provided for STEM learning. In vignette 4, Kira does this by explaining e.g. "You know what daddy does when he doesn't want his trailer to move? He puts a rock under the wheel and then the trailer doesn't roll anywhere". We can see how this interaction provides conditions for conceptual play when Paige goes on to explain that the jeep is rolling down the hill and then gathers Kira's shoes, using them as rocks under the wheels of the jeep to stop it's roll.

Similar to Disney and Li (2022) our research reports that collective imaginary play is not enough to support conceptual thinking. It is not until the parent steps inside the play, tunes into the children's thought processes and then guides children to use conceptual thinking processes that conceptual play takes place. Through entering the imaginary play, parents are able to better understand the child's play and conceptual learning needs and respond to these.

The conceptual thinking observed in Vignette 4 is complex and is made possible through a sustained thinking process involving imagination and Kira's intentional teaching. At first, Paige places the shoes in front of the wheels, but then after some consideration she realises that if the jeep is rolling backwards then the shoes should be placed behind the wheels.

The CPW challenged Kira's thinking about the relationship between imagination and concept formation. Whilst at the commencement of the study Kira had understood independent positioning as being the only worthwhile type of pedagogical positioning to take in relation to imaginary play, we now see a new family pedagogy developing which values the relationship between conceptual thinking and imagination. Kira explains her genuine surprise in observing Paige's ability to use imagination to solve the complex scientific problem of the jeep rolling down the hill, and explains this to be a large learning shift for Paige in the study. This is described in Vignette 5 below.

Vignette 5.

Kira	*I thought, when we were saying that it (the jeep) was rolling down a hill and the problem solving around how we were going to stop that or how we were going to help that, and the way that she corrected where the rocks go behind the wheels herself, little moments like that I thought were fantastic, without it even being on a hill or rolling anywhere, she used her mind to work out that it would roll backwards. These sorts of things, they are quite easy when something is rolling, to be like, oh, I need the weight on the back sort of thing, but when it is all imaginative it was really remarkable to see that she understood that and went from there.*

As Paige's conceptual thinking develops, so too does her play. This makes sense to us given our understanding that play is a source of development and therefore needs to be a step ahead of conceptual development (Lindqvist, 1995). Complex conceptual play is seen when Paige imagines "the relations between observable contexts and non-observable concepts" (Fleer, 2019 p. 1), such as when she pretend that Kira's shoes are rocks and places them behind the wheels of the imaginary jeep to stop it from rolling down the hill which does not exist.

5.1.7. Below position

When Kira initiated a below position, asking rhetorical or basic questions within an imaginary narrative, this placed Paige in a powerful position to contribute conceptual knowledge. In Vignette 5 which follows, we notice that Kira asks Paige a question which she knows (from the first section of the vignette) that Paige has the ability to answer. We see that by positioning herself in an under position, space is provided for Paige to demonstrate her conceptual understanding and contribute her knowledge to the collective situation.

Vignette 5.

A conversation within the CPW takes place moments prior where all three play partners (Kira, Paige and the researcher) attempt to pull the jeep up the hill using a rope which Paige has secured to the vehicle. After several attempts, Kira tells Paige that jeeps and cars are too heavy for people or animals to pull uphill.

Kira	*Could you pull my car?*
Paige	*No! (Confidently shakes head)*
Kira	*No? No, I don't think so*
Paige	*(Shakes her head to indicate her agreeance with Kira)*

When a teacher assumes the below position, their role is to provide space for the child to take initiative or solve problems (Fleer, 2015), and we see this frequently in Kira and Paige's interactions. In the example above where Kira asks Paige "Could you pull my car?" Paige is able to solve this problem immediately with a certain "No". When Paige responds to the questions with "No" and Kira says "No? No, I don't think so", the condition has been provided for Paige to experience success in contributing to the STEM conversation. This vignette again reminds us of the dynamic nature of effective pedagogical positioning. Kira is able to use below positioning to enable Paige to contribute conceptual knowledge, only because moments earlier, she positioned herself above Paige to explain that jeeps and cars are too heavy for people or animals to pull uphill. Had Kira not positioned herself above Paige to introduce this prior conceptual knowledge, we argue that Paige may not have been able to answer "No" with such confidence.

Table 5
The relationship between parental development of a collective imaginary situation and new opportunities for STEM conceptual thinking, with optimal conditions and affordances highlighted.

Pedagogical Position	Parent perspective	Developmental affordance
Independent	Parent is on the outside of the child's imaginary play. Interaction comes in the form of providing props and allowing the child time and space to play.	Imaginary play occurs with the child creating their own activities. As the child draws from life experiences to create a play scenario, this dramatisation is a product of collectives.
Equal	Parent verbally acknowledges the child's ideas but does not build upon them. Encouragement is provided and the parent may join in with the already existing play themes or anecdotally comment on what the child is doing.	
Below	Parent uses rhetorical or easily understood questions to support Child's conceptual thinking.	Child contributes conceptual ideas to the imaginary narrative.
Above (Within the imaginary narrative).	Parent contributes new ideas to the imaginary scenario and the child then builds on these ideas.	Parent and child interact in an imaginary space.
Key finding		
Above (Within the solving of the STEM problem).	Parent brings new ideas to the imaginary scenario in the form of STEM concepts.	Parent and child interact in a conceptual space.

5.1.8.

In Table 5 below, we synthesise all of our aforementioned findings to show the relationship between imagination and conceptual thinking.

5.2. Discussion of the interpretations

Our interpretations of the results of our research have identified four pedagogical positions used by Kira and the influence these have on Paige's STEM concept formation. Previous work on pedagogical positioning by Fleer (2015) and Kravtsov and Kravtsova (2010) reports on the classroom teaching-learning context, and we identify significant parallels with their research in the understanding of parent-child interactions in the home setting.

Column 1 of Table 6 lists the 4 interactive moments categorising the way an adult interacts in a child's imaginary play as described by Fleer (2015). In the study reported on in this paper, our thematic interpretation of imagination and conceptual thinking in the family setting showed that in the absence of the CPW, Kira interacted independently of Paige's imaginary play. However, data captured within the CPW intervention, when categorised, were reflective of the three other dynamic positioning types originally found in Kravtsov and Kravtsova's (2010) work. Column 2 of Table 6 presents the types of positioning Kira demonstrated throughout the study and where these positions sit in relation to Fleer's (2015) categories.

As the study reported on in this paper focuses not only on imaginary interactions but also on conceptual interactions, our description of parent positioning expands upon Fleer's, 2015 model to describe parent interaction in relation to STEM. Accordingly, the additional finding which we contribute to Fleer's model is the distinction that when, in the above/primordial we position the teacher models and explains content knowledge which relates either to imaginary themes or to STEM concepts.

Column 3 of Table 6 identifies the specific developmental conditions which each of the 4 types of interactions afforded Paige. As described with vignette examples throughout our discussion of results, affordances were identified through the process of noticing how Paige responded to each of the 4 types of interactions initiated by Kira.

6. Conclusion

Whilst Vygotsky (2004 p.17) argued that “imagination is a completely essential condition for almost all human mental activity”, very little is understood about how parents can create these conditions that bring together imaginary play and STEM learning opportunities for their children. This study evaluated the effect of an intervention using CPWs on a parent's ability to actively support their preschooler's STEM learning through collective parent-child engagement in imaginary play. We used the concept of pedagogical positioning (Fleer, 2015), which categorises imaginary play interactions between adults and children into dynamic groups, each of which afford different developmental conditions, as a tool for analysis of both imaginary play and conceptual learning.

Our first finding relates to Vygotsky's (2004) explanation that children create imaginary play scenarios by drawing from their life experiences. The findings of our study suggest that the parent can create conditions for this imaginary play to unfold when they position themselves independently of the play. Our data tells us that this independent positioning provides space for the child to combine elements of reality grasped from their prior impressions to generate imaginary play (Vygotsky, 2004). However, for the child to have elements of reality stored in their memory to draw from, parents must first have provided the conditions for the child to engage in rich life experience. Vygotsky (2004, p. 15) stresses, “the richer a person's experience, the richer is the material his imagination has access to”. In this paper, we explain how Paige's parents provided her with opportunities to engage in all aspects of family activity to develop “life skills”, and how these experiences were used by Paige to develop imaginary play narratives when playing independently at home.

Our second finding relates to Kravtsov and Kravtsova's (2010) perspective about a child being both inside and outside a play scenario. Kravtsov and Kravtsova explain that when a child is looking at their imagination “from the side”, they are then able to master the important skill of controlling the plot, which in turn affords the development of imaginary play. It appears that when the parent uses equal positioning, verbally acknowledging the child's ideas and asking questions, conditions are created for the child to control

Table 6
Pedagogical positioning and STEM related developmental affordance in the family setting.

Pedagogical Positioning Model (Fleer, 2015)	Parent Positioning (This study)	Developmental Affordance
Independent	The parent is on the outside of the child's imaginary play.	The concept of collective imagination is present as the child draws on memory of prior interactions to create their own activities.
Equal	The parent verbally acknowledges the child's ideas but does not build upon them.	The child narrates their own ideas within the collective imaginary space.
Above and Primordial we	The parent brings new ideas to the imaginary scenario. Some of these ideas have clear links to STEM concepts.	The new ideas and concepts form part of the child's experiences and some of them are reappropriated in future play when other forms of positioning are provided.
Below	The parent inquires about the child's understanding through the use of rhetorical questions.	The child experiences being in an above position and contributes conceptual information.

their play narrative from both within and outside the scenario.

Thirdly, Vygotsky (1998) argued that imagination is a learned skill requiring adult mediation. Our findings indicate that a parent can effectively support a child's developing imagination by positioning themselves above the child within the imaginary narrative and then introducing ideas about the plot. This new understanding helps us better understand how Vygotsky's argument can be used by parents in practice. Our fourth finding builds upon the work of Fleer (2015) who found that when a teacher initiates a below position, asking rhetorical or basic questions within an imaginary narrative, this places the child in a powerful position to contribute conceptual knowledge. We confirm that in the present study, this also occurred in parent-child interactions.

The fifth and key finding of the present study is that when the parent entered into an imaginary scenario with the child and then, at the same time, pedagogically positioned herself above the child by introducing new conceptual information, a more advanced form of STEM learning occurred. These findings suggest a synergy between how teachers and parents pedagogically position themselves to effectively provide motivating conditions for conceptual development (eg. Disney & Li, 2022; Fleer, 2015). This correlation highlights the powerful role of families in driving STEM learning during the preschool years. It may be argued that when parents are provided knowledge about how to support STEM learning through conceptual play, their role is as effective in conceptual development as that of teachers.

An important aspect underpinning our findings in this study is that, as also discovered by Fleer (2015) and Disney and Li (2022) when analysing teacher pedagogical positioning, parent positioning must be dynamic in nature if conceptual development is to be afforded.

The conclusions drawn from this study must be viewed with caution because they are based on interactions in one family. We have a larger data set showing similar parent pedagogical positions and developmental affordances across a larger quantity of families. However, due to word limitations, we only discuss findings of one family in this paper. One issue for consideration is whether Kira and Nathan's values, beliefs and traditions in relation to play and conceptual learning are reflective of family perspectives globally, or subject to a western centric gaze. In modern western industrialised societies, most parents see the importance of imaginary play and traditions in family homes play a large role in providing conditions for children to develop imaginary play competencies (Hedegaard, 2016). However, research tells us that different families play with their children in distinctive ways, and that there is diversity in how children in different stages of development relate to the play initiated by adults (Hedegaard & Fleer, 2013). Pre-intervention data capturing parent pedagogical positions in play may vary between families and these variations may influence the impact of the CPW intervention.

Another consideration is the variation which exists in parental capacity to provide optimal STEM learning conditions. A recent literature review about parental involvement in early childhood STEM education conducted by Salvatierra, Cabello (2022a, 2022b) explains that a parent's level of academic experience with science does not pose limitations nor advance their ability to teach STEM concepts to their children. However, we assume that a parent who has pre-existing STEM knowledge will be better placed to introduce conceptual knowledge to a child than one who does not. Further research involving a larger cross section of cultural, global and socioeconomic perspectives is required to better understand how differences in family practices influence the conditions created by the CPW intervention.

Another aspect to consider is the influence of gender related STEM practices in family homes. The present study focused on interactions between a mother and child, however in Vignette 4 we see how Paige is reminded of the way Nathan uses a rock to stop the roll of a trailer, and then uses this knowledge to solve a conceptual problem. Further studies involving direct interactions between children and their fathers would provide us with a more nuanced understanding of how fathers use pedagogical positioning to create conditions for STEM learning, and how involvement in a CPW intervention shifts these interactions.

The Conceptual PlayWorld approach is a promising model of practice for altering the current situation where parents feel anxious and unsure (Johnston et al., 2022) about how to approach STEM learning with their children, or hold misconceptions about preschoolers' abilities to learn STEM concepts (eg. Dorie et al., 2014; Larkin & Lowrie, 2022). From a methodological perspective, if used in future research, the CPW model has the potential to generate data which helps us to tangibly understand how parents can interact with children in home settings to provide conditions for STEM learning. Marcus et al. (2017) explains that for parents to generate meaningful STEM learning outcomes, the intervention they receive must apply to the home setting rather than just community settings such as museums and libraries. This home intervention approach is also suggested by Salvatierra, Cabello (2022a, 2022b) who, in their literature review, argue that current findings in the 'STEM and families space' could be deepened and validated through the use of more sophisticated study designs. As presented in this paper, when used as an intervention in daily practice, the researcher is able to begin by collecting baseline data about interactions between family members and then find changes in interactional patterns and developmental affordances as the intervention occurs.

CRediT authorship contribution statement

Sonya Nedovic: Writing – review & editing, Writing – original draft, Investigation, Formal analysis, Data curation, Conceptualization. **Marilyn Fleer:** Supervision. **Prabhat Rai:** Supervision.

Declaration of competing interest

The authors declare no competing interests.

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