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Conceptual PlayWorld: Creating Motivating Conditions for New Kindergarten Practices in China to Support Engineering Education

Abstract

In recent times, engineering education has increasingly emerged as a valued kindergarten practice. Engineering teaching in play brings challenges for Chinese kindergarten teachers. An educational experiment (EE) was conducted to support teaching in this area to help Chinese kindergarten teachers face this challenge. Qualitative data including video data and interview transcripts were collected in a public kindergarten located in a Chinese provincial capital city. Participants included one focused teacher and 28 children aged four to five years. In the context of early childhood education, drawing upon a cultural-historical perspective, we study how engineering pedagogical practices changed under the conditions of an intervention, called an engineering Conceptual PlayWorld (CPW). The findings show a shift in the focused teacher's subject positioning, and new practice contexts in which an engineering pedagogy emerged. We argue that a CPW created the motivating conditions for Chinese kindergarten teachers exploring new engineering pedagogical practices, wherein they realised a new form of collective imaginary play and designed new engineering pedagogies for teaching young children.

Keywords: Cultural-historical theory; Conceptual PlayWorld; engineering pedagogy; Chinese cultural context.

Introduction

Engineering is a subject that can be used to facilitate connections and learning across STEM (Tank, Rynearson, and Moore 2018). In addition, engineering applies material resources or scientific knowledge to solve problems (Bagiati & Evangelou, 2015; Fleer, 2019; Lippard et al., 2017), which is valued in the kindergarten context. However, it is difficult for teachers to design play-based engineering (Tian, 2019), in responding to Chinese government policy. Therefore, we sought to set up an educational experiment (EE) (Hedegaard, 2008) where we worked with early childhood teachers to support a change in their practices so that teachers can meet the policy requirement (Ministry of Education, 2012a). This paper begins with an international literature review of engineering education, then shifts its focus to engineering education in a Chinese context. The study then presents a cultural-historical theoretical discussion of the concept of play, followed by an analysis of a teacher's subject positioning in engineering activity. Finally, the paper concludes with a discussion of the teacher's pedagogical changes and the implication for teaching engineering in a play-based setting.

Literature Review

The significance of engineering teaching in kindergartens is recognised globally (Fleer, 2021; Lippard et al., 2017). Kindergarten environments are full of possibilities for children to learn about engineering because they provide important materials and social contexts to support children's engineering activities (Bagiati & Evangelou, 2015; Fleer, 2019, 2020). In addition, young children engage engineering concepts to solve problems in their daily practice (Lippard et al., 2018). It has been found that a well-designed engineering education benefits children in their problem-solving strategies, creative thinking, engineering literacy, spatial concepts and executive function development (Gold et al., 2021; Reifel, 1984). A well-designed early engineering program for young children is key to supporting their engineering learning (Forbes et al., 2018; Lippard et al., 2017; Park et al., 2017). Yet engineering practices in China do not reflect this (Tian, 2019).

Promoting children's engineering thinking should be considered as an important engineering teaching agenda (Lippard et al., 2017), which leads to an increasing expectation of teaching engineering in Chinese kindergartens. The expectations put further challenges on teachers, as it appears that they worry that teaching academic knowledge is contradictory to the government requirement of teaching in play-based settings (Qian, 2020). Although studies indicate that a playful environment provides opportunities for children to explore engineering (Fleer, 2019), Chinese kindergarten teachers still need support in engineering teaching (Cai et al., 2021), creating an environment for children to initiate their learning (Ma et al., 2022), and intentionally promoting children's engineering thinking in play (Lippard et al., 2017).

What is unique about education in kindergarten is that teaching should be conducted in play-based settings, including engineering teaching. In the context of Chinese kindergartens, play is highly valued and emphasised in early childhood education policies. Specifically, kindergarten education is expected to provide children with play-based learning opportunities that foster their initiative in learning (Ministry of Education, 2001; Ministry of Education, 2012b).

In this study, early engineering play describes the relationship between early childhood development and education in the field of engineering (Bairaktarova et al., 2011). It is defined as 'young children's observable thought processes specifically related to design in the context of construction' (Gold et al., 2015, p. 2). Based on this argument, construction activity is an important engineering behaviour of young children (Bairaktarova et al., 2011) which is emphasised in Chinese early childhood context. As indicated by the *Early Learning and Development Guidelines for Children Aged 3–6* (Ministry of Education, 2012a), constructing a bridge can be seen as an engineering activity that children experience in kindergarten daily practice. The concept of the load-bearing capacity of a bridge is an engineering concept that young children learn through opportunities to engage in construction type activities, such as block building in their play. The policy orients Chinese kindergarten teachers to draw more attention to construction activity in young children's engineering education. Therefore, construction activity is specifically focused on in this study as the context of the research question.

Although early engineering education is emphasised in China, research indicates that teachers' engineering skills need improvement. Specifically, the research shows that teachers need support in how to interact with children in engineering contexts (Shao, 2016) and to develop their observation skills (Tian, 2019) in construction activities. This highlights the need for teachers to enhance engineering pedagogy so they can better support young children's learning in engineering contexts such as construction activity.

Professional development programs are proven effective ways to support teachers' engineering education. For example, Tian (2019) finds that Chinese teachers' construction teaching competence can be improved through ongoing support from the researcher. The finding echoes what is known internationally that effective professional development supports change in teacher practices (Lippard et al., 2017; Park et al., 2017). Although professional development support kindergarten teachers' engineering teaching in multiple ways, less attention has been directed to supporting Chinese teachers' engineering pedagogies in play through interventions. To contribute to filling this gap, and to support Chinese kindergarten teachers' engineering education in play, a play pedagogy called Conceptual PlayWorld (CPW) (Fleer, 2018) was applied through collaborative work between teachers and researchers to enrich kindergarten children's engineering concept teaching in play.

The Conceptual PlayWorld Approach

Research has shown that a CPW approach helps teachers use imaginary play to support children's conceptual learning (Fleer, 2018) which makes it possible for engineering concepts to be brought into children's play. Drawing on the cultural-historical concept of play, Lindqvist (1995) developed an aesthetic play pedagogy to understand children's development in play, terming it 'playworld'. The 'playworld' pedagogy has been conducted across various countries such as U.S. (Ferholt & Lecusay, 2009), Finland (Hakkarainen, 2010), Australia (Fleer, 2017), and China (Ma et al., 2022). Based on the successful implementation of a Scientific Playworld (Fleer, 2017), Fleer (2018) further developed the CPW approach. In a CPW, the imaginary play usually follows a known fairy tale or children's book with dramatic moments, so that children and teachers can build empathy with the characters (Fleer, 2019). Following the storyline, teachers and children enter an imaginary space full of dramatic problems that need to be solved using conceptual knowledge. Having empathy with the characters motivates children to help the characters solve the engineering conceptual problems within the CPW (Fleer, 2019). The methodology section provides a detailed presentation of the implementation process of the CPW.

The CPW can support engineering teaching in Australia (Fleer, 2019, 2020; Lewis et al., 2019) and support local conditions and societal needs in China (Fleer & Li, 2020; Ma et al., 2022). Given these findings, our study introduced a CPW as a pedagogical approach to support Chinese kindergarten teachers' engineering teaching in play. The study aimed to examine the implementation process of CPW in the Chinese cultural context by undertaking an educational experiment (EE) designed around a two-fold research question: *Under the conditions of a planned intervention of a CPW in China, do teacher practices change? How do the teacher's pedagogical practices bring forward engineering play and learning within imaginary situations?*

Theoretical Framework

The study employs the cultural-historical theory to frame the research. Recognising the significant role of play in fostering children's engineering learning, we will begin by defining play from a cultural-historical perspective.

Play is defined as the creation of an imaginary situation, in which children and adults change the meaning of objects and actions, giving them a new sense within an imaginary play situation (Vygotsky, 1966). For example, when engaging with engineering play, a block can become a wall, reflecting how children understand and conceptualise the abstract concept of a 'wall'. When children and teachers are negotiating with each other and giving new meanings to an object, they are collectively imagining the same imaginary situation (Fleer, 2013) which supports the introduction of engineering concepts in the collective imagining possible. In play, teachers amplify engineering education for kindergarten children (Fleer, 2020a). In addition, teachers need to involve in collective imaginary situations by taking different positions to make sure the player's goal can be captured (Kravtsov & Kravtsova, 2010). By doing so, intentional support can be provided to facilitate children's learning of engineering concepts during play.

The cultural-historical concept of subject positioning (Kravtsova, 2009) also guides this study to interpret a teacher's engineering pedagogical changes. Subject positioning conceptualises a teacher's position in relation to children or the other teacher in pair pedagogues (Kravtsova, 2009). The subject positioning can be described in five positions (Kravtsova, 2009): above the child, when a teacher is leading the play by providing suggestions to children; equal with the child, when teachers and children equally negotiate ideas in play; below the child, when children are leading the play; a child is independent of the teacher, when children are playing without a teacher but still engage in the play; and in a primordial we position, when a teacher plays as a model to engage children's participation in play. In response to the research aim, the paper understands a teacher's *engineering pedagogical changes* in play by interpreting the shift of her subject positioning within an educational experiment (Hedegaard, 2008).

Methodology

In this paper, a cultural-historical theory is used to frame the study of teachers' engineering teaching in the Chinese social context. Vygotsky (1998) argued that development should be understood in relation to the cultural environment. From a cultural-historical point of view, development is interpreted as a process dialectically related to the cultural context rather than a linear process (Fleer, Fragkiadaki, and Rai 2020). Therefore, development should be observed in a naturalistic setting (Hedegaard, 2008a), leading us to use an *educational experiment* (EE) (Hedegaard, 2008a) to frame our study.

An EE includes researchers, teachers, and children in the same context (Hedegaard, 2008a). An EE is a multifaceted planned intervention around a theoretical problem, and not just a problem of practice, which some research has shown to create conditions to motivate teachers' development within a naturalistic setting (Fleer, Fragkiadaki, and Rai 2020). Through our EE, we introduced a CPW to teachers as an intervention to see if and how a kindergarten teacher changed her engineering pedagogy in play.

Research Setting and Participants

This study took place in a public kindergarten located in a provincial capital city in the Northeast of China. The big study focused on two classrooms to ensure high-quality professional development. Class A's CPW was more engineering-oriented following the selected book. Therefore, Ms Zhao from class A (age 4–5 years, mean 4.5 years old) was the focused teacher in this paper to help understand the development of her engineering pedagogy during the CPW. Ms Zhao held a four-year university bachelor’s degree and had 16 years of teaching experience. Pseudonyms were used in the study.

Study Design

To capture teacher’s potential pedagogical changes, this EE was conducted in three phases as presented in Table 1. Digital video observation was used to document the teacher’s pedagogical practices. A total of 55.34 hours of video observation data were collected in this study. Three cameras were used in the study focusing on the perspective of the teacher, children, and the whole classroom respectively. The data also support the interview process for the teacher to reflect on her previous teaching practices. The data collection included pre-implementation data collection, CPW implementation and post-interviews.

Table 1. Three phases of the educational experiment

	Phase 1	Phase 2	Phase 3
Professional development activities	Professional development workshop (3 hours)	Focus group discussion with teachers and ongoing reflection (10.15 h)	Post-interview with the teacher (1 h)
	Pre-implementation data (13.28 h)	CPW implementation (27.91 h)	

The first phase captured the pre-implementation data that focus on teacher’s engineering teaching practices. Then a professional development workshop (over two sessions) was conducted to introduce the CPW to teachers, and then teachers had a chance to design CPW with the researchers.

The second phase involved focus group discussion and the CPW implementation following the five characteristics of the CPW (presented in Table 2). The focus group discussion mainly included collective reflections with the researchers on the previous session of the CPW and planning for the next session. There was a total of 10.15 hours of focus group discussion collected through video recording. In this paper, we focus on one teacher's (Ms Zhao's) engineering teaching before and during the implementation of the CPW to capture her engineering pedagogical changes.

Table 2. The Conceptual PlayWorld implementation

Five Characteristics of the Conceptual PlayWorld (Fleer, 2018)	**Conceptual PlayWorld (CPW): Breg's Tornado**
Selecting a story for the Conceptual PlayWorld	A translated French children's book, *Breg's Tornado* (Boy, 2006) was selected by the teacher and researchers considering children's interests.
Designing a Conceptual PlayWorld space	The classroom was imagined as the farm that had been partially destroyed by the tornado.
Entering and exiting the Conceptual PlayWorld space	In this CPW, the teacher and children entered the imaginary farm as characters in the story, such as Mummy Rabbit, Little Lamb, and Little Pig.
Planning the play inquiry or problem scenario	Engineering problems were proposed following the storyline for children to solve with the teacher, such as how to rescue a little rabbit from a tall tree or how to construct a stronger bridge for the farm.
Planning teacher interactions to build conceptual learning in role	The teacher selected a role she would pretend in the CPW and planned how to interact with the children as characters within the imaginary situation.

The third phase included post-interviews with the teacher, aiming to capture the teacher's pedagogical reflection after the CPW implementation. One hour of post-interview data was collected, which focused on the teacher's perspective and aimed to understand her experience of teaching in the CPW.

Ethical approval was granted by the authors' university Human Research Ethics Committee. Informed consents were obtained from the participating kindergarten, teachers, and families before data collection. In line with the research questions, this study focuses on the teacher's pedagogy in an engineering context, such as construction activity.

Data Analysis

To obtain a holistic view of the teacher's pedagogical practices and change, the digital data was analysed using the three levels of interpretation (Hedegaard, 2008b): common-sense interpretation, situated practice interpretation and thematic interpretation.

First, at the level of *common-sense interpretation*, the researchers documented their understanding of the interaction between the teacher and the children. How the teacher supported the children's play and engineering learning was identified from the data set.

Second, *situated practice interpretation* aimed to 'transcend the single activity setting and link together observations taken across several activity settings' (Hedegaard, 2008b, p. 58). The patterns of the focus teacher's engineering pedagogies across different activity settings were explicated using theoretical concepts (play and subject positioning) at this level.

Thematic interpretation builds on the situated practice interpretation and is directly connected to the aim of this research. The concept of subject positioning (Kravtsov & Kravtsova, 2010) was used to explain the pattern of the teacher's engineering pedagogy to answer the research question. The data was analysed in an upward spiral way (Li, 2019) following the three levels of interpretation instead of a linear process. Therefore, the data can be iteratively visited through a theoretical lens to make sure the data was analysed in a valid way. In addition, this study obtained a holistic view of the changes in a kindergarten teacher's engineering pedagogy that took place because of the implementation of CPW.

Findings

By capturing the teacher’s subject positioning and practices in engineering, we identified that Ms Zhao changed her engineering pedagogy in the construction activity settings (see Table 3). This section presented evidence of how CPW as a new play pedagogical approach created conditions for the focus teacher to change her engineering pedagogy. Two typical examples were presented to show the pedagogical changes. Vignette one depicted Ms Zhao’s engineering pedagogy before the implementation of CPW, while Vignette two presented her pedagogy within the CPW. Vignette two included three parts that provide evidence of how the collective imaginary situation within the CPW, motivated Ms Zhao to dynamically position herself while interacting with children, thus supporting children’s engineering play and learning.

Table 3 Ms Zhao’s engineering pedagogical practices before and during the CPW

Session	Pre-implementation data		Conceptual PlayWorld				
Engineering oriented sessions	What is a joint	Small groups activity	Rescuing the little rabbit – building ladders	Delivering woods – making a truck	Fixing the bridge -- making a strong bridge	Fixing the bridge -- making a strong bridge	Rebuilding our farm – building a new kindergarten
Teacher’s subject positioning	**Above the child:** Ms. Zhao was leading the play as a teacher **Child was independent of the teacher:** children were engaging in the engineering play to solve a problem.		**Above the child:** Ms. Zhao was leading the play as a play partner. **Equal with the child:** Teacher was in collective play as a play partner and equally negotiate ideas with children. **Below the child:** Ms. Zhao was being inside children’s play as a play partner and giving more spaces for children to take initiative in concept learning. **Child was independent of the teacher:** children were engaging in the engineering play to solve a problem.				
Teacher’s engineering pedagogy	• Teacher was engaging with children as **a teacher** • **Teacher was leading** the teaching activity • Teacher was staying **outside** of children’s play • **Direct** engineering teaching		• Teacher was engaging with children as **a play partner** • Teacher gave more chances for **children to take the initiative** in their learning • Teacher was being **inside** children’s play and presenting more positionings • **A dynamic relation** between children’s participation and teacher’s engineering teaching was formed.				

Vignette 1: Above Position in Construction Skill Teaching

This vignette presented the linear process of engineering pedagogy before the CPW intervention. The teacher was taking the above position, her instruction was not aligned with children’s learning intention (as presented in Fig.1).

In the presented activity, children were designing and constructing different buildings with blocks in the construction area. Ms Zhao's educational purpose was to teach a construction skill. To do this, she encouraged the children to prototype the structure shown in the picture. Ms Zhao claimed her leading position by proposing several questions when she entered the building area (as shown in Fig.1):

> "Do you remember we built a wall last time? Right? Which one did we build? Which picture on this wall (The three pictures on the wall presented different constructing strategies of building a wall， which were prepared by the teacher)?"

Qiqi: This one (pointing to the first picture).

Ms Zhao: Now let's build this wall, quick!

After the conversation, instead of building a wall, the children were engaged in their own work. No one was building the structure shown on the wall.

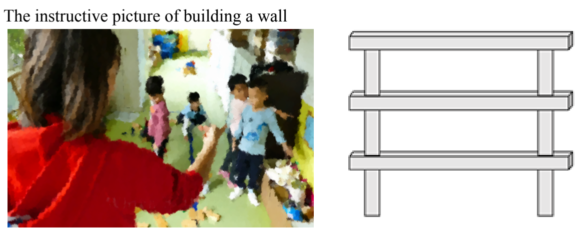


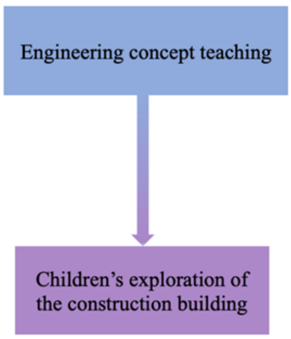
Fig. 1 Ms Zhao above the children in the pre-implementation data

This vignette presented the teacher's engineering pedagogy of constructing a strong structure before the CPW implementation. Ms Zhao provided direct instructions on constructing play outside the imaginary situation, recognising her own leading role and above position as a teacher. This pedagogy was also acknowledged in Ms Zhao's comments in the pre-implementation data.

"Play is not blind. It is important, as a teacher, you need to have a rule in your mind and to lead children's play using your language or behaviour." *(A-PI-T).*

The construction skill that can support children's building activity. However, the teaching agenda didn't become personally meaningful to children. In this vignette, Ms Zhao was outside the imaginary situation. Her intention was to teach the construction skill, which is different from the children's intention of constructing buildings. Therefore, the children didn't respond back to the teacher. The engineering concept teaching was conducted in a linear way, see Fig. 2. The vignette indicated that understanding children's intentions was the key for the teacher to support engineering play. The CPW was found as an effective method to support the teacher to achieve this goal, as shown in Vignette two.

Fig. 2 Linear way of engineering instruction



Vignette 2: A Dynamic Position in Construction Skill Teaching

The imaginary situation within the CPW allowed the teacher to dynamically position (Disney & Li, 2022) herself in engineering teaching to meet children's learning demands. A dynamic relation between children's actively participation and Ms Zhao's engineering teaching was found within the CPW, presented in Fig.3. When Ms Zhao and the children shared the same imaginary situation in the CPW, they shared the same goal (building a strong bridge). This allowed the teaching goal to become personally meaningful to the children. Vignette two was divided into three parts to detail how Ms Zhao dynamically positioned herself within the CPW, alternating among above, below, and equal positions.

Vignette two was selected from the seventh session of CPW, aiming to help children understand a construction skill: increasing the number of piers can increase the load-bearing capacity of a bridge. Different from the pre-implementation data, this engineering design activity was set up in an imaginary scenario.

A bridge in the farm was destroyed by the tornado and needed to be rebuilt. This created an engineering problem for children to solve. Ms Zhao and the children entered the imaginary situation to build a bridge as play partners. Different materials were provided to build piers and decks: cans for the pier and one piece of paper for the bridge deck.

Part 1: Above Children in the Imaginary Play

At the beginning of the vignette, Ms Zhao was above the children and standing in the middle of the classroom, trying to lead the bridge deck building, as presented in Fig. 3.

(Children were busy with their own work)

Ms Zhao: Listen, little animals, please listen to me. Don't rush to test if the bridge is strong enough, you can set the bridge deck well first…

Ms Zhao: Then … then listen to me. You can use two pillars as piers. Next, put the paper bridge deck on top.

(Children not paying attention to Ms Zhao)

Fig. 3 Ms Zhao above the children in the CPW

At this moment, Ms Zhao was trying to lead the session as she did in pre-implementation data. However, the children were so excited and focused on their own work inside the imaginary situation that Ms Zhao's leading role was ignored. The emotionally charged situation motivated children to take the initiative and identify an engineering conceptual problem. Children focused on the building activity that they paid less attention to the teacher's instructions.

Part 2: Being Equal with Children in the Imaginary Play

The following session presented how one child, Xing motivated the teacher to change her position from above to being equal with the children. Ms Zhao's participation in the imaginary play enabled her to understand the children's needs and work equally with Xing to solve the problem (Fig. 4).

Xing: Ms Zhao, could you give me one more pillar?

Ms Zhao: Why should I give you one more?

Xing: It's not strong enough.

Ms Zhao: Okay, this bridge is not strong. Why? (Squatting down with the child)

Xing: I have a good idea!

Ms Zhao: Ah! What is it?

Xing: I can put them (materials for testing the load-bearing capacity) into a rectangular shape.

In this section, Xing took the initiative and identified an engineering problem (the bridge is not strong). As the teacher and children were sharing the collective imaginary situation and aiming to build a strong and safe bridge, Ms Zhao quickly captured the critical moment to explain the construction skill and equally discuss the problem with Xing.

Fig. 4 Ms Zhao equally negotiated ideas with Xing in the CPW

Part 3 Being with Children in the Imaginary Play

As Xing proposed a possible solution to solve the engineering problem, Ms Zhao followed Xing's lead and proposed an engineering problem for Xing to solve by taking a below position, see Fig. 5.

Ms Zhao: But a bridge needs to bear lots of (materials). What can we do about that? (Ms Zhao positions herself in a below position and prompts children to explore further about this conceptual problem)

Xing: We can do this.

Then Xing put two bridge piers nearer to each other and added another pier (pier 3) under the bridge floor, as presented in Fig. 6. In this way, the problem-solving process became personally meaningful to Xing, and he was able to apply the new ideas to solve the engineering problem he identified ("*It [the bridge] is not strong enough"*). We can notice that children's active exploration motivated the teacher to take dynamic subject positions in engineering teaching. Ms Zhao also made her own reflection in relation to this aspect at post-interview, stating that

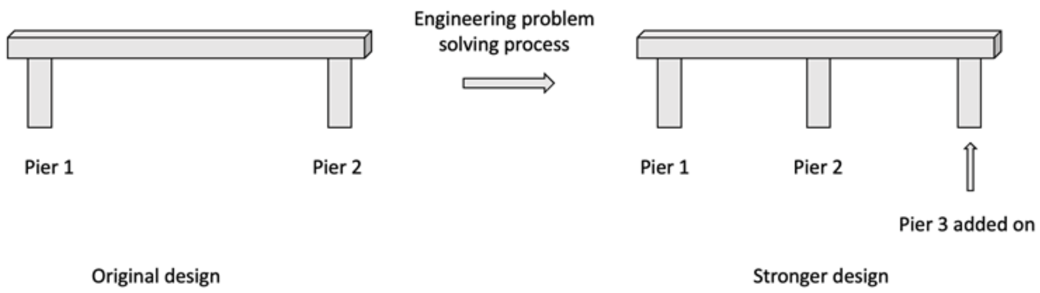
"In the CPW, I built an equal relationship with the children made me feel that the children are more capable than you (colloquial Chinese, meaning 'us adults'). They were able to integrate different engineering knowledge into the CPW and they surprised me a lot." *(A-FI-T)*.

Ms Zhao acknowledged the children's active engagement as capable explorers and realised her important role as a play partner to understand children's perspectives. Compared with the teacher's role in children's construction activity before the implementation of CPW, she valued children's thoughts and focused more about children's intentions within the CPW.

Fig. 5 Ms Zhao's below position in the CPW

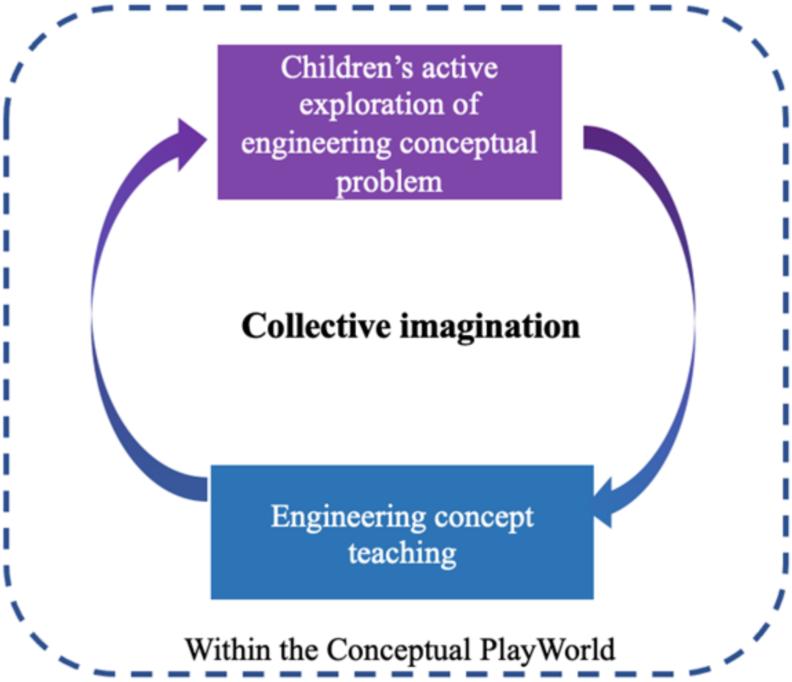
In the shared imaginary situation, Ms Zhao can easily capture children's intentions (Fleer, 2020a) and dynamically change her position among above, equal and below to support children's exploration of the engineering problem.

Fig. 6 Xing solved an engineering problem using a construction skill



Vignette two presented the importance of aligning the teaching goals with the children's play motive. In this scenario, both the teacher and the children were working towards constructing a strong bridge. A shared imaginary situation in CPW allowed the teacher and children to share the same goal (building a strong bridge). The children's active exploration motivated Ms Zhao to position herself dynamically in supporting children's engineering thinking. In addition, the shift of engineering pedagogy supported children's engineering learning in play, as presented in Fig.7.

Fig. 7 Dynamic relation between teacher's instruction and children's exploration in engineering CPW



Discussion

The study identified that in the CPW, Ms Zhao's subject positioning changed from only taking an above position in the pre-implementation of CPW to taking dynamic positions to meet children's demands in engineering exploration. Thus, it led to three engineering pedagogical changes. These changes are discussed below.

Teaching Engineering Concepts through Engineering Play

Taking the dynamic positions led Ms Zhao to shift her engineering teaching from 'direct instruction' to 'teaching within collective imaginary situations,' which meets the policy requirement of supporting children's learning in play-based settings (Ministry of Education, 2001). The first vignette only involved a superficial level of engineering teaching, imitating a prototype picture on the wall. Ms Zhao was above the children and the teaching goal was misaligned with the children's learning goal (Kravtsov & Kravtsova, 2010). The teaching goal was not personally meaningful to the children, so they were not motivated to deeply learn the construction skill through active exploration.

In the CPW, the collective imaginary situation allowed Ms Zhao to share the same goal related to the exploration of the engineering conceptual problem. Ms Zhao as a play partner, was able to take dynamic positions in making responses to children's demands in solving the engineering conceptual problem. As a result, Ms Zhao successfully supported children to build a strong bridge using construction skills (e.g., Xing added one pier to make the bridge stronger). Collective imagination in CPW fosters engineering teaching, by serving as a resource for pedagogical changes for teachers (Fleer, Fragkiadaki, and Rai 2021). Therefore, we argue that the collective imagination in CPW can support kindergarten teachers' new practices in engineering education in the Chinese cultural context.

Furthermore, we found that within the CPW, the teacher shared the play experience with children and worked towards the shared goal, thus, engineering problems became personally meaningful to both teacher and children. This aligns with the finding of other studies (Lippard et al., 2017; Cai et al., 2021) that when supporting children's engineering learning in play, teachers can intentionally interact with children's engineering thinking to realise engineering concept teaching. Within the engineering CPW, the teachers addressed the challenge of teaching engineering in play and met the government demands of 'teaching in play' (Ministry of Education, 2001).

Giving the Opportunities for Children to Lead Their Engineering Exploration

In this paper, we echo the argument by Disney and Li (2021), to explain that the dynamic subject positioning within CPW enables Ms Zhao to provide more possibilities to children in engineering learning. Before the implementation of CPW, Ms Zhao was observed taking an above position and being outside of the children's imaginary play. She directly instructed children to explore construction skills, aiming to meet her engineering teaching goal. This resulted in the teacher having less discussion with the children. The educational goal was not shared with the children's play motives. Therefore, children lost their interest in following the teacher's instruction, as they did not have lots of opportunities to lead and explore the engineering concepts.

Within the CPW, Ms Zhao and the children were involved in play as play partners. Ms Zhao can sensitively expand children's engineering play within the collective imaginary situation (e.g., proposed follow-up engineering problem for Xing to solve). In the meantime, the teacher offered opportunities for children to express their ideas, initiate engineering thinking and promote rich conversations (e.g., Ms Zhao asking questions to promote Xing's thinking and exploration). To conclude, the CPW created conditions for the teacher to dynamically shift the pedagogical positions to motivate children to take initiative in their learning and to support children's engineering thinking in play, as suggested by Lippard (2017) and Fleer, et al. (2017).

Building a Dynamic Relationship Between Engineering Teaching and Learning

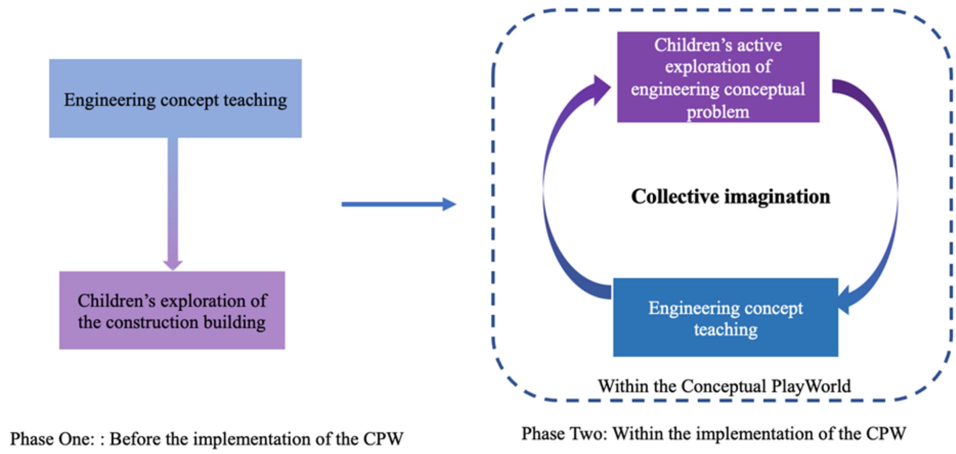
A dynamic relationship was observed between engineering teaching and learning within the CPW. As explained in the first vignette, the activity was teacher-directed and did not motivate children's conceptual learning, resulting in limited exploration and progress. The activity was conducted in a linear way by the teacher's direct teaching, as presented in Phase One of the project (see Fig. 8).

The interaction between the teacher and children was shifted when they were inside the play through the implementation of the CPW (e.g., more engineering conversations happened in the CPW). This example was reflected across the children involved in the CPW. In the CPW, children became responsible and intentional problem solvers (Ma et al., 2022). Taking one step further, our study finds that children's initiative in engineering learning motivated the teacher to shift her engineering teaching pedagogy and changed her subject positioning in play.

The second vignette demonstrated how Ms Zhao used dynamic positions to support children's construction skill learning. ***This positioning shifting was not initiated by the teacher; rather,***

it was motivated by children. A dynamic relationship between children's active participation and the teacher's engineering pedagogical change in play was shown within the collective imaginary situation, as presented in Phase Two of the project (see Fig. 8).

Fig. 8 Teacher's engineering pedagogy changes through the educational experiment



Taken together, three engineering pedagogical changes were observed within the CPW, including Ms Zhao changing her engineering pedagogy from 'direct teaching' to 'teaching engineering through play', giving more space for children to lead their concept learning, and building a dynamic relationship between engineering teaching and learning. Gold, et al (2015) has argued that teacher plays an important role in helping children engage in engineering-related tasks and foster the development of skills and concepts related to engineering. In this paper, we have extended the work by Gold and his colleagues (2015), emphasising that CPW enables the teacher to change her role and position in play to proposing engineering problems and asking open-ended questions for children to solve. CPW approach promotes the interrelationship between teaching and learning, which supports teachers to enhance children's engineering play and exploration.

Conclusion

The expectations of the Chinese cultural context put demands on kindergarten teachers to foster children's academic learning in play-based settings (Barenthien et al., 2020; Ministry of Education, 2001). However, it is argued that these requirements are challenging for Chinese kindergarten teachers (Qian, 2020), and they need support to improve engineering teaching in play (Cai et al., 2021). The present study may help teachers overcome the challenge of teaching engineering in play. The findings respond to the research questions by presenting the three practical changes of the teacher in the engineering educational context. The practical changes support children's deep engineering learning in play and promote the teacher's engineering pedagogical in play.

The findings of the study suggest that CPW provides a powerful tool for kindergarten teachers to motivate children's active participation in construction skill learning, aligning with government policy (Ministry of Education, 2012a). The CPW remains the concept teaching demanded by Chinese kindergartens (Lin, Li, and Yang 2019). What has changed in the CPW is the teacher's pedagogical practice - shifted from delivering engineering concepts to motivating children to take the initiative and identify engineering problems. Therefore, the CPW sheds light on supporting Chinese kindergarten teachers' engineering teaching in play.

Further, as a cultural-historical study, this paper explores the development of a teacher's engineering concept teaching in relation to the social environment. The playful environment that a CPW creates gave the possibility for the children to actively participate in the engineering learning process. The active exploration provides positive feedback for the teacher's engineering pedagogical development. This motivates the teacher to change the teaching practices to be more in line with the children's engineering learning intention. As a result, a dynamic relationship between the children's engineering learning and the teacher's engineering teaching is built within the play.

Taken together, the CPW in this social context appears not only to create conditions for the teacher to support children's deep engineering learning in play, but also to promote the teacher's engineering pedagogical changes in play. The result of the paper suggests the possibility of engineering teaching in play-based settings through implementing the CPW within the Chinese cultural context.

Limitation

The study is limited due to the short data collection period during the COVID pandemic. Further research is needed to understand the impact of pedagogical changes on teachers' professional development and the sustainability of change. In addition, to get an insight into the teacher's practical change, this study only focuses on one teacher in one Chinese kindergarten. This creates chances for further exploration but also limits generalizability.

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