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A cultural-historical study of how children's mathematical learning becomes personally meaningful in the collective imaginary play within the Chinese kindergarten context

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A cultural-historical study of how children's mathematical learning becomes personally meaningful in the collective imaginary play within the Chinese kindergarten context

Previous studies have emphasised that play can promote children's learning of mathematics. However, little research has been directed towards understanding how collective imaginary play motivates children's meaningful mathematical learning. Informed by the cultural-historical conception of play and motives, this paper examines how Conceptual PlayWorld creates conditions for Chinese children's mathematical learning. Video observations of teachers interacting with children (4-5 years) during the Conceptual PlayWorld implementation (8.54 hours), as well as children's interviews (5.75 hours), were gathered and analysed. The findings show Conceptual PlayWorld created mathematical conditions that promote children's thinking, imagining and play. Besides, children's dominating motive of play can be regarded as a context in which meaning-giving motives guide children to build mathematical narratives. Further, children's motives for mathematical learning are stimulated by their play motives which are amplified through participation and problem-solving in a Conceptual PlayWorld, and this creates conditions for Chinese children's personally meaningful repeating pattern learning.

Keywords: Meaningful learning; mathematics; repeating pattern; Chinese kindergarten; playworld

Introduction

Early mathematical learning benefits children's personal-social, fine motor, language, and gross motor development, as well as their later school achievement (MacDonald & Carmichael, 2018; Taner Derman et al., 2020). Considering the importance of mathematics, early mathematical learning is highly valued in China (Zhang et al., 2020). Mathematics is embedded in the science domain in the Guidelines for Kindergarten Education Practice in China (Ministry of Education of the People's Republic of China, 2001). With the play-based curriculum reform, Chinese teachers generally support constructive than transmissive

mathematical teaching approaches (Wang et al., 2022). However, teachers reported difficulties in teaching mathematics in a meaningful way at the kindergarten level (Hu et al., 2017). As a result, nowadays some Chinese teachers tend to adopt the fusion of structured teaching and child-directed learning (Yang & Li, 2018). For example, a typical mathematics lesson in a contemporary Chinese kindergarten classroom consists of a teacher introducing a topic, children participating in one to three games or activities on the topic, and children reporting back (Li et al., 2019). Under this situation, researchers indicate that a remarkable amount of teacher-child mathematical interactions were mainly subject-centred and teacher-directed, and did not show children's active participation and meaningful learning (Hu et al., 2017). Further, the research undertaken in China with preschool children learning mathematics also showed that teachers mostly focused on counting and calculation, which Yang et al. (2022) reported as being 63.89% of their instruction. Chinese teachers are good at situating counting and calculation into a meaningful everyday context (Yang et al., 2022). However, how children can learn mathematical concepts other than counting and calculation in a meaningful way is poorly understood. To address this problem, this paper uses the repeating pattern as an illustration to explore children's personally meaningful mathematical learning in a collective imaginary situation within the Chinese kindergarten context.

Children's pattern learning in early childhood education

Early pattern learning represents a form of relational reasoning and lays key foundations for young children's mathematical thinking and subsequent mathematical development (Bojorque et al., 2021; Miller et al., 2016). According to Björklund (2016), a pattern can be regarded as a repeated phenomena that follows a predictable order. Particularly, a repeating pattern is a periodic sequence of elements that can be reduced to a 'unit of repeat' (Lüken & Sauzet, 2021). A range of tasks were used to assess and foster young children's repeating

pattern learning. To be specific, children's duplicating (or copying) and extending (or fixing, interpolating) of patterns, generalising of patterns (producing the same pattern using different materials or modes), identifying the unit of repeat in a pattern as well as creating patterns are examined (Lüken & Sauzet, 2021; Miller et al., 2016; Rittle-Johnson et al., 2019). It is commonly accepted that generalising, finding the unit of repeat and creating patterns are more complex tasks compared to duplicating and extending a pattern (Lüken & Sauzet, 2021; Rittle-Johnson et al., 2015). Through exploring children's strategies when working with repeating patterns, Lüken (2020) found that older children focus more on regularity and structure than younger children. For example, the 5-year-old children mainly used comparison and classification (e.g., looking and comparing with the pattern's beginning), and they focused on sequence (e.g., what is coming next) while working with patterns. However, most of these studies on children's pattern skills and pattern learning were based on the operation of concrete materials and objects, such as arranging blocks and making beaded bracelets (Lüken & Sauzet, 2021; Tsamir et al., 2020). Although play offers a possible way for children to learn how to combine features and follow rules in patterns (Björklund, 2016), we know little about children's patterning learning in imaginary play (Li & Disney, 2021), particularly in the Chinese kindergarten context.

Imaginary Play and children's mathematical learning

In considering the literature in meaningful mathematical learning through imaginary play, a few researchers have theorised and empirically studied this area. Papandreou and Konstantinidou (2020) come up with a participatory play pedagogy which illustrates that children can achieve meaningful mathematical learning when their emerging mathematising was listened to, valued and seriously considered by teachers in the imaginary play. Considering mathematics as a cultural activity, van Oers (2010) develops the concept of

‘meaningful learning in a double sense’, which includes cultural and personal meaning. Cultural meaningful learning is based on actions, goals, tools and symbols, while personally meaningful learning is related to personal values and motives (van Oers, 2010). Meaningful learning is conceived as a way of learning through personally meaningful participation in cultural practices (van Oers, 2010, 2012b). To be specific, in a play-based activity, children not only use mathematics to serve their play activities, but also elaborate further on specific mathematical learning (Broström, 2017; Worthington & van Oers, 2016). For instance, in the shoe-shop example (van Oers, 2010), children spontaneously started to try shoes in their play, while the teacher stimulates the mathematical activities in different directions (categorising, selling and buying shoes), which leads to mathematical learning (e.g. adding and subtracting) based on children’s play. Building on the conceptualisation of meaningful learning (van Oers, 2010), Li and Disney (2021) further developed the concept meaningful of mathematical learning. Through their research in Australia, they investigated children’s mathematical problem-solving in a collective imaginary play context and analysed the children’s meaningful mathematical learning. For example, they find that children are motivated to solve a dramatic problem (no two dogs sitting together) where the meaningful pattern learning process was shaped as if they were at the witch’s birthday party (Li & Disney, 2021). In this way, play offers potential contexts that situate meaning-making, and allow children to solve mathematical problems in a meaningful way.

Framed in a cultural-historical perspective where play and learning are featured, these studies show how meaningful mathematical learning emerges in play. However, Chinese children’s personally meaningful pattern learning in imaginary play was less known. In line with Li and Disney’s (2021) study on children’s meaningful mathematical learning, this study aims to explore how Chinese children, who come from a Confucian cultural background, learn repeating patterns in a personally meaningful way. In the next section, we briefly present our

conception of play and the core concept of motives, which are significant in exploring Chinese children's personally meaningful mathematical learning.

Cultural-historical conceptions of play and motives

The cultural-historical conception of play

The cultural-historical conception of play was firstly introduced by Vygotsky (1966) as the creation of an imaginary situation, in which children change the meaning of things and actions, giving them new senses. In speaking of play and its role in young children's development, Vygotsky (1966, p. 6) argued that play 'is not the predominant form of activity, but is, in a certain sense, the leading source of development in preschool years'. Based on Vygotsky's work, Elkonin (1999) developed 'play being the leading source of development' to the 'leading activity' for young children. The leading activity for preschool children in cultural-historical literature is play (Elkonin, 2005; Leontev, 1981). However, only with all play elements fully developed and taking mature forms, can play become the leading activity of preschool and kindergarten-aged children (Bodrova, 2008). There are three characteristics of mature play (Bodrova & Leong, 2015). First, children use object substitutes to symbolise the objects and use gestures to represent actions. Second, children take on and sustain a specific role by consistently engaging in actions, speech and interactions associated with the pretend scenario in a mature form of play. Third, children engage in play scenarios that integrate different themes and a long-time span (several days or even weeks). The Conceptual PlayWorld (CPW) model (Fleer, 2018) as a form of mature play was used in this study to create conditions for children's meaningful repeating pattern learning. Lindqvist (1995) first introduced the playworld approach, which allows children and adults to enter imaginary situations and dramatise play plots based on stories. Based on Lindqvist's (1995) playworld, a CPW allows teachers to introduce conceptual problems in play, and therefore conceptual

concepts are introduced in service of the children's play. In this study, CPW creates conditions for children's personally meaningful mathematical learning by promoting children's play.

Children's motives development

Children's motive development in practice provides a possible way to maintain children's personally meaningful learning (Li & Disney, 2021). Hedegaard (2002) theorised motives and identified different kinds of motive orientations: dominating motives, meaning-making motives and stimulating motives. *Dominating motives* are associated with the type of activities that are central and important to a person's life (Hedegaard, 2002). Dominating motive is regarded as children's leading motive; for the preschool child, play motives are the dominating motives (Fleer, 2014). Dominating motives can be used as *stimulating motives* to develop other motives and stimulate activities which are not motivating at the beginning (Hedegaard, 2002). Stimulating motives emerge when teachers created motivating conditions in the PlayWorld for conceptual teaching and learning (Fleer, 2021). It could be a problem to be solved in imaginary play, which engages children and motivates them to solve problems using mathematical concepts in a personally meaningful way. *Meaning-making motive* dominates a person's self-expression. As argued by Hedegaard (2002), dominant motives are always meaning-giving motives because they guide children in a particular way. Meaning-giving motives where the relations between a child's motives and the social situations that orient children in particular ways which make sense for the child (Fleer, 2020). By using Hedegaard's (2002) theorization of motives, our study aimed to explore how children's dominating motives of play developed as meaning-making motives (building adventure narratives) and stimulating motives (solving a play problem using repeating patterns) in the Chinese kindergarten context. Children's stimulating motives further stimulate mathematical learning motives, which create conditions for children's personally

meaningful mathematical learning. In this way, we build on Li and Disney's (2021) conception of stimulating motives in meaning making, and examine in detail how children's dominating motive and meaning-making motive development lay the foundation for their personally meaningful mathematical learning.

Study design

Research contexts

Based on cultural-historical theory, this study was framed as an educational experiment (Hedegaard, 2012), where the CPW approach was used to promote Chinese children's conceptual learning through play in everyday settings. Ethical approval was obtained from the researchers' university (Project number 7851). Both the staff and child consent forms were collected before we conducted the study (child consent forms were signed by their parents). Additionally, teachers' and children's pseudonyms are used in this study to increase confidentiality.

Research participants

The data reported in this paper involved one classroom in one public kindergarten located in Changchun city, Jilin province. In this classroom, 34 children (mean age: 4.65 years old) and two teachers participated with signed consent forms. Both of the teachers (Ms Li and Ms Han) in this class held a diploma in early childhood education and teaching.

Procedure for data collection

According to Hedegaard (2012), activity settings are events located in practices based on the cultural traditions of different institutions. The CPW activity settings within the Chinese kindergarten institution are the primary interest for this study. Researchers cooperated with teachers to implement the CPW by providing ongoing support through Zoom meetings before

each session. Three cameras were used in the baseline and CPW data collection, capturing teachers' perspectives, children's perspectives and the whole activity setting respectively. Zeng, a boy aged four years and six months, is one of the focus children in digital video observation and his pattern learning was examined in this paper.

Apart from digital video observation, child interview data were collected to obtain a clear view of children's perspectives. The first author conducted *stimulated recall interviews* (Lyle, 2003) twice through Zoom (recorded) as a little fairy with the assistance of the other researcher who was on-site. One child interview was conducted in the middle of the CPW implementation, and another one was at the end. During the stimulated recall interview, video clips and pictures were used as prompts when interacting with children, and questions asked were based on the children's experiences in the CPW activity settings. For example, the researcher asked children how they solved problems while they went on adventures under the sea. For example, 'How did you find your seats in the submarine? How did you feel in this activity?'. As shown in Table 1, eight CPW sessions were conducted in this class based on *The Snail and the Whale* (Donaldson, 2003). Among these, two CPW sessions that focused on mathematics (3rd and 4th CPW, total 8.54 hours) and children's interview data (5.75 hours) were discussed in this paper.

Table 1. Overview of eight Conceptual PlayWorld sessions.

CPW	1st CPW session	2nd CPW session	3rd CPW session	4th CPW session	5th CPW session	6th CPW session	7th CPW session	8th CPW session
Play problem	How to avoid the storm	Helping the snail to go on an adventure	Finding a seat in the submarine	Is the boat full?	Saving the whale	Making a paper boat	Testing the boat	Designing a submarine

Data analysis

Drawing upon the wholeness child development model, this study adopted Hedegaard's (2008) three-level data interpretation protocols (see table 2). The data analysis is an iterative

process, which allows a deeper understanding of how CPW created conditions for children's personally meaningful mathematical learning.

Table 2. The data analysis process.

Common sense interpretation	Step 1	The video observation data and interview data were logged with content summaries.
	Step 2	Data were tagged about children's mathematical learning when the CPW was introduced.
	Step 3	Data were tagged when children imagined, appeared to exhibit behaviours and make comments in relation to play narratives and characters.
Stimulated practice interpretation	Step 4	Based on the previous three steps of interpretations, video data were cut into video clips and put into corresponding folders, which enabled the identification of a density of data related to children's meaningful mathematical learning. For example, researchers found children were motivated to use mathematical concepts to solve problems in the CPW activity settings.
	Step 5	Common trends and themes were identified and named according to the situated practices, such as solving dramatic mathematical problems.
Thematic interpretation	Step 6	In line with the research question and theoretical concepts informed, theoretical links were made to different data folders. For example, the cultural-historical conception of play and motives were used to analyse if, when and how children changed the meaning of objects and actions in their play, which informs play and learning motives development.
	Step 7	The sample video clip was selected to illustrate and highlight the main findings of children's meaningful mathematical learning within the CPW (answer the research question).

Findings

The analysis revealed the motivating conditions created by the CPW in supporting the focus child Zeng's personally meaningful pattern learning. The findings illustrated (1) how Zeng built emotional connections within the collective imaginary situation and developed *dominating motives of play*, (2) how play narratives promote Zeng's *meaning-making motives of continuing adventure in the submarine*, and (3) how Zeng was stimulated to solve a mathematical problem (*stimulated motive*) related to repeating patterns in play and develop his learning motives.

A dominating motive of play: Building emotional connections with the character roles and in the collective imaginary situation

This study found a dominating motive of play was encouraged in the CPW. The selected vignette was based on children's interests in helping the land snails go on adventures with sea snails in the previous CPW session. In this example, the teachers (Ms Li and Ms Han) invited the children to choose their play characters (either a land snail or a sea snail) and gave them corresponding stickers and objects. Ms Li told the children:

> 'Sea snails love water, so I have prepared water (in paper cups) for sea snails. If sea snails feel dry, they can sprinkle some water onto their bodies. Also, this is the first time for the land snails to travel under the water, so I have prepared goggles for them in case they feel scared'.

As a sea snail, Zeng got a sea snail sticker and a cup of water. Ms Li and Ms Han played active roles as a submarine captain and a crew member respectively.

The CPW created conditions for children's play motives (dominating motives) development by providing children opportunities to build a relationship with their play roles in the collective imaginary situation. Firstly, children were given stickers (land snail stickers and sea snail stickers) and objects (goggles and water cups) to represent their roles, which helped them build close connections with the characters they played. For example, while waiting for other children, Zeng sprinkled water on his head as if he was a sea snail suffering from body dryness (see figure 1). This shows that Zeng built connections with the role, and behaved as a sea snail following the sea snail behaviours. Secondly, teachers' active roles in the CPW helped create a collective imaginary situation, which promoted children's play development. For example, when Ms Li played the role of submarine captain, she put on her glasses and held a round plate, acting as if she was holding the steering wheel and operating the submarine. Later she invited all snails to enter the submarine (the sleeping room), with the

sound ‘Gollum’. This gave the foundation for imagining with more complexity in a mature form of imaginary play by promoting the movement between ‘individual imagining’ and ‘collective imagining’ (Fleer & Hedegaard, 2010). Later, when children were asked if the activities in CPW are the same as their regular collective (mathematical) activities in the stimulated recall interview. The focus child Zeng said, ‘it is different, this (the CPW) is play, our regular activity is learning’. Chinese children distinguish play from non-play, where play is self-initiated, motivated and enjoyable (Wong et al., 2011). By creating a collective imaginary situation and encouraging children to play character roles, the CPW aligns with children’s dominating motives of play in the Chinese kindergarten context.

Figure 1. Zeng put his fingers into the water cup and sprinkled water as a sea snail.

A meaning-giving motive of continuing adventure in the sea: Building meaningful play narratives

The play narratives in this CPW were built by children and teachers based on the storybook *The Snail and the Whale*. The original story is about one little snail’s adventure with a whale in the sea. Together they went on an amazing journey, past icebergs and volcanoes, sharks

and penguins, and the little snail helped the stranded whale in the end. Children and teachers collaboratively added new plots to the original story and built up rich play narratives in their CPW imaginary adventures (see figure 2). In this CPW, children received a message from a fairy, saying they can find a submarine on the beach. Ms Li further built up the play narratives and suggested snails follow the patterns of 'one sea snail and two land snails' when they find seats in the submarine:

> You know that sea snails went into the water many times, but this is the first time land snails go into the water. The land snails might feel nervous, so when you find a seat you should be mindful that one sea snail should stay with two land snails. In addition, the sea snail should sit in the first place, followed by two land snails.

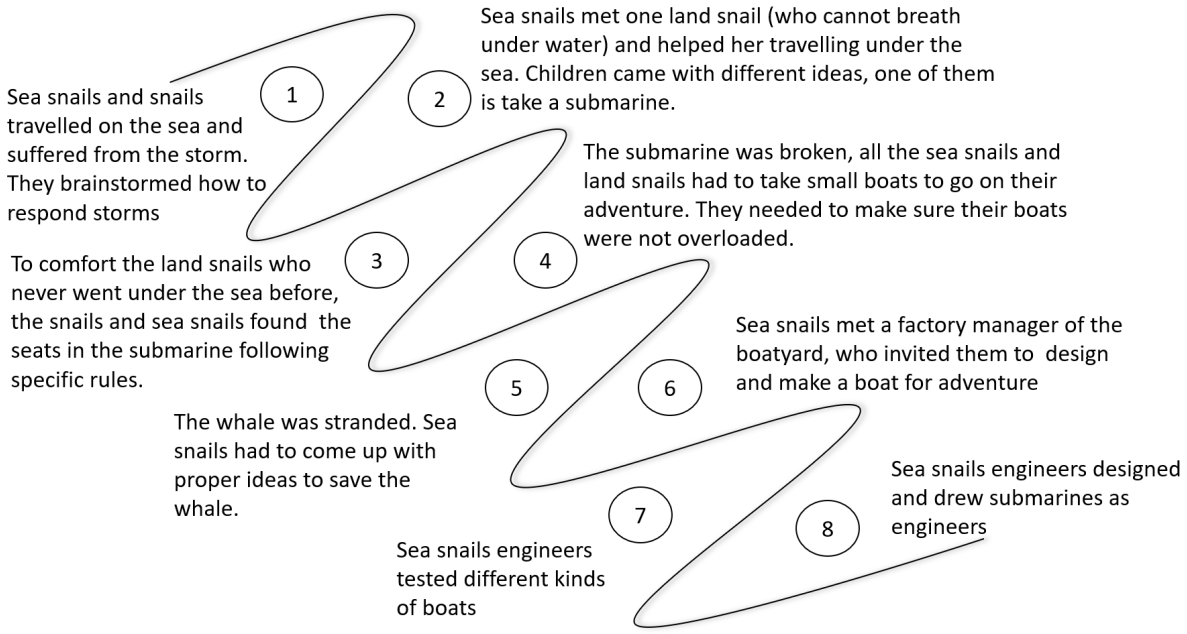

Figure 2. The play narratives built in the eight Conceptual PlayWorld sessions.

The sea snails developed sympathy for the land snails who have never gone underwater before; in contrast, the land snails had a clear awareness that they needed to sit following a sea snail because they would be nervous during their first trip under the sea. Since the play narrative was built based on children's ideas and interests and guided children in their play,

the meaning-making motives of continuing adventure in the sea and building play narratives made sense for them. In CPW, play narratives provided meaningful contexts for children to structure mathematical ideas and solve a problem related to repeating patterns, which promoted children's personally meaningful mathematical learning in the Chinese kindergarten context. As argued by Björklund and Pramling Samuelsson (2013), the use of narrative means that the teacher tries to give the learning object meaning within an interesting and familiar story context.

A stimulating motive for solving dramatic problems: Children's exploration of repeating patterns in play

After the children built connections with the characters and familiarised themselves with the play narratives, the teacher raised a dramatised problem to promote children's repeating pattern learning. Chinese children hardly have opportunities to experience dramatic tensions in mathematical learning (Li et al., 2019). However, in this study, Ms Li raised a dramatic problem based on the narratives in which children were interested. This was a play problem that required problem-solving based on the repeating pattern, finding seats following the 'one sea snail and two land snails' rule. According to Lindqvist (2003), adults need to dramatise the action to provide play with meaning. This dramatic problem provided a possible way to promote children's meaningful learning in repeating patterns. For example, the focus child Zeng hung out in the submarine, trying to find a seat following the rules. While walking, he met the captain who asked him, 'did you find your two land snails?' (generalising the unit of repeat). Zeng shook his head and said 'no'. At this time, one sea snail reminded Zeng, 'The submarine was about to start'. Zeng checked the seats from the beginning (see figure 3), and then he noticed that there was an empty seat before two land snails. He quickly sat down in that seat. When Ms Li (the captain) came to check if all the snails were in the right seats, following the 'one sea snail and two land snails' pattern, Zeng said to her, 'look, I am a sea

snail, and these (on the right side) are two land snails who follow me'. Ms Li responded to Zeng, 'great job, sea snail! You are in the right seat'. Ms Li then checked the seating pattern with all the children, they together said 'one sea snail and two land snails', 'one sea snail and two land snails'…

Figure 3. Zeng was looking for a seat in the submarine.

Zeng found the right seat following the 'one sea snail and two land snails' pattern in play, which was an illustration of children trying to fix the pattern and generalising the unit of repeat (Wijns et al., 2019). For Zeng, the stimulating motive is to find two land snails and sit with them. Thus, Zeng kept trying to find the right seat during the whole CPW session. Especially when he heard that the submarine was going to start up, his motive of finding the right seat was stimulated. The problem scenario brings a new motive orientation which is to sit according to the repeating pattern before the submarine starts. When solving this problem, Zeng was able to use the 'one sea snail and two land snails' patterns to solve the mathematical problem in a meaningful way. Children's meaningful learning of repeating patterns was also shown in the child interview, where children explained to the researcher

‘we sit in the submarine according to the pattern of *one sea snail and two land snails*’.

Discussion

Our educational experiment in which we worked together with teachers to implement a CPW, found that children’s personally meaningful pattern learning in play was possible in the Chinese kindergarten context. As shown in figure 4, we found there is an interdependence between play motives and learning motives in the CPW activity settings, which promotes children’s meaningful mathematical learning. Firstly, CPW provides motivating conditions for children’s play motives development. To be specific, it encouraged Zeng to role-play in the collective imaginary situation, build up narratives and solve dramatic mathematical problems, thereby promoting the development of dominating motives, meaning-making motives and stimulating motives. Secondly, children’s stimulating motives stimulate learning by motivating children to solve dramatic mathematical problems, which allows personal meaningful mathematical learning. For example, Zeng was motivated to find a seat following the ‘one sea snail and two land snails’ pattern in the collective imaginary play. We suggest embedding Chinese children’s learning motives for mathematics (such as repeating patterns) into play motives, thereby contributing to a better understanding of the mathematical learning of children in Chinese kindergartens.

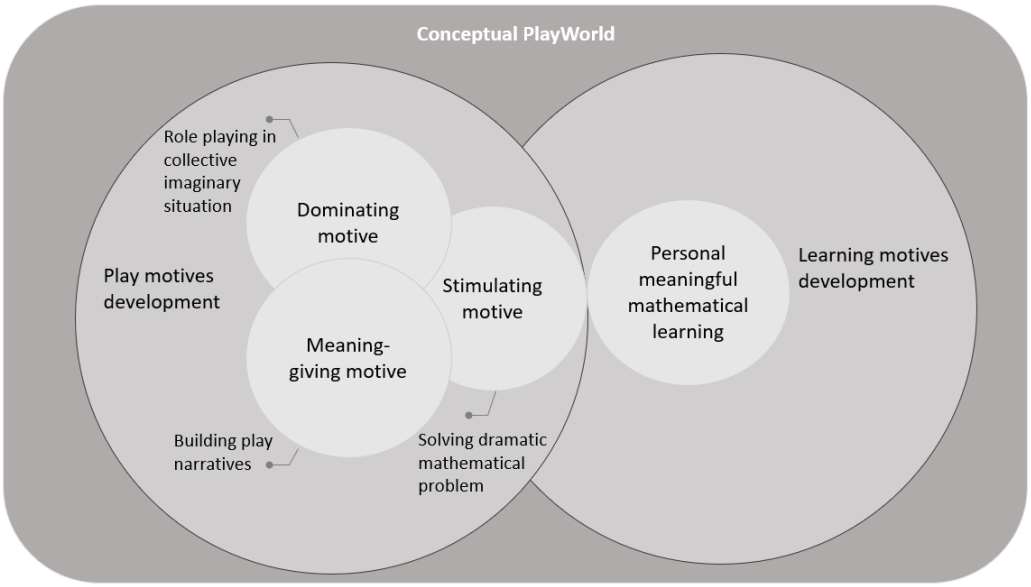

Figure 4. An analytical framework of children's meaningful learning in repeating patterns in Conceptual PlayWorld.

Motivating conditions for mature play: Developing children's play motives in a meaningful way

Since many teaching sessions in Chinese kindergartens consist of teacher-directed play-oriented activities where teachers either lead play or organise activities in a playful manner, children do not have a lot of opportunities to develop their play motives in group teaching (Wu, 2019). Therefore, there is a need to promote the children's role in play and shared control in mathematical learning (Wickstrom et al., 2019). In the mathematically oriented CPW activity settings, children are given some degree of freedom to role-play and construct rules within the imaginary situation (Ma et al., 2022). In this way, the dominating motive of play was able to develop within the collective imagination as we saw the focus child Zeng playing the role of a sea snail and interacting with other characters. As argued by van Oers (2012a), the process of personal meaning-making starts with children's engagement in cultural practices which make personal sense to them, and in which they want to participate. By providing collective imaginary situations and meaningful narratives, the CPW

engaged children and developed their meaning-making motives, such as going on an adventure and finding a seat in the submarine. This corresponds to Fleer's (2012) argument that children are more likely to develop play motives when the activity is motivating and connected to their interests and experiences. In this way, children's dominating motive of play could be regarded as a meaning-making motive because they were able to build play narratives which make sense to them.

Involved in collective imaginary play, children were stimulated to follow a specific pattern to find seats in the submarine, which was a part of children's dominating motive development. From the children's perspective, they have a clear consciousness that one sea snail should sit with two land snails. For example, when Zeng tried to find a seat before two land snails, the stimulating motive stimulated his personally meaningful learning of patterns. Although children thought they were playing in the submarine, they were involved in fixing the pattern with a conscious awareness of the unit of repeat (Lüken & Sauzet, 2021). In summary, CPW promotes children's play motives development, which includes role-playing as snails (dominating motive), building play narratives (meaning-making motive) and finding seats as snails following the pattern (stimulating motive). This helps explain, as Li and Disney (2021) originally identified, how character roles helped children build emotional connections, dramatise the problem and develop stimulating motives. In this study, we go one step further by exploring how children's dominating and meaning-making motives develop, as well as how children's stimulating motive development lays the foundation for personal meaningful mathematical learning in the Chinese kindergarten context.

Stimulating children's learning motives: Promoting children's personally meaningful mathematical learning

From a cultural-historical perspective, learning is not a linear process, but a spiral process of thinking and problem-solving (Li & Disney, 2021). Drama created dual emotional responses

when the child was engaged in role-play (Vygotsky, 1966), and this allowed a motive orientation in promoting children's mathematical problem solving in play (Li & Disney, 2021). As shown in this study, when children are stimulated to solve a dramatic mathematical problem in play, their play motives can be motivated by learning motives. To be specific, the dramatic play inquiries embedded helped children explore repeating patterns in a personally meaningful way as we saw the focus child Zeng fixing the pattern. This allows children to pay attention to the surface features as well as the overall structure of the pattern as the problem emphasises the unit or repeat and its generalisation (Wijns et al., 2019). Meaningful learning is important for the cultural development of human beings who wish to engage in and contribute to their community's cultural practices (van Oers, 2012b). However, the most fundamental problem of mathematics education in China is that activities do not make sense to children (Hu et al., 2017). Apart from the problem of mathematics, the impact of children's engagement and experience of play has not yet been fully understood in China (Fleer & Li, 2020). In CPW activity settings, the problem dramatisation was based on play narratives (travelling by submarine under the sea) that children find fascinating, which is why they can comprehend what has occurred (Lindqvist, 2003). In acting out the characters in the storybook (as if they were snails and sea snails in the submarine), children were motivated to solve conceptual problems following the repeating pattern, which promotes their personally meaningful mathematical learning.

Different from previous studies which explored children's repeating patterns through asking children operating materials (Lüken & Sauzet, 2021; Tsamir et al., 2020), this study focused children's repeating pattern learning in an collective imaginary situation. Meanwhile, in contrast to traditional Chinese mathematical learning where repeated exercises were emphasised (Dai & Cheung, 2015), this study emphasized children's active problem-solving

process and personally meaningful learning in repeating patterns. When Zeng showed Ms Li that he was sitting with two land snails, it could be seen that he had successfully solved the problem by identifying the missing parts of repeating patterns. Therefore, when the problem scenario was introduced with drama, imagination, and meaningful narratives, it became possible for Chinese children to engage with mathematical discipline knowledge for expanding their play. As shown in the data, Zeng's peer reminded him the submarine was going to start soon, which further motivated Zeng's pattern learning in play. In summary, the CPW also provided a possible solution to the problem (Hu et al., 2017) raised, where she argued mathematical lessons in Chinese kindergartens lack critical moments in children's meaning-making. Through analysing Zeng's play and learning experience, we found that the stimulating motives of solving the play problem can motivate children's learning motives, which created conditions for children's personally meaningful mathematical learning in the Chinese kindergarten context.

Conclusion

While the call for high-quality experiences in early childhood mathematics is not new, this study provides motivating conditions through an educational experiment for Chinese children's mathematical learning in the repeating pattern. From a cultural-historical perspective, mathematics should be embedded in meaningful contexts (Dijk et al., 2004). However, it is widely known that schools tend to focus on the transmission of codified cultural meanings (disciplinary knowledge) while ignoring the personal sense such knowledge may have for the students (van Oers, 2012b). Especially in the Chinese context where content knowledge and teacher authority have been emphasised for a long period (Faas et al., 2017; Wu & Rao, 2011). A possible solution to this phenomenon is that children and teachers go in and out of play, imagining 'as if' in the imaginary situation and reflecting on

the real world ('as is'), while teachers in their elaborations conceptually develop the mutual play frame (Pramling et al., 2019). For young children, meaningful learning is conceived as a process that is related to play (van Oers, 2008). In particular, when problem-solving and practice are interwoven in play, meaningful learning is much more effective. The CPW model provided a creative solution to develop Chinese children's play motives. When children's learning motives development are embedded in play motives, children's personally meaningful mathematical learning were prompted. By illustrating children's meaningful repeating pattern learning, this study offered a possible way for children's meaningful mathematical learning in areas other than calculation and counting in the Chinese kindergarten context. In addition, this study contributed to expanding what is known about meaningful mathematical learning.

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