CONCEPTUALIZING AN EXPERT TEACHER'S EXPERTISE IN A LESSON DESIGN STUDY IN SHANGHAI

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This paper proposes a conceptualization of an expert teacher's expertise by coordinating a subject-based behaviour/cognitive analysis and a social-culturally situated analysis. Data from our Lesson Design Study in Shanghai, China, included lesson plans, transcripts of the video-recorded lessons, and transcripts of commentary on the lessons by the expert teacher was analysed. This showed the attunements of the expert teacher to the affordances and constraints of the activity system. This conceptualization of the 'dual nature' of the expert teacher's expertise contributes to a deep analysis of the unique and significant functions of the expert teacher in China.

INTRODUCTION

Li and Kaiser (2011, pp. 6-8) have highlighted three key issues regarding teacher expertise in mathematics education: (1) "identifying teachers with expertise"; (2) "specifying and analyzing aspects of teachers' expertise in mathematics instruction"; and (3) "understanding expertise in mathematics instruction that is valued in different cultures". Subsequently and more recently, Kaiser and Li (2017, p. 81), in a Research Forum at PME41, argued for the need to explore "possible relationships between (subject-based) cognitive and (social-culturally) situated perspectives" in examining and evaluating teachers' competencies and expertise.

In this paper, we make a contribution to conceptualizing the nature of a Chinese expert teacher's expertise in our Lesson Design Study (LDS) in Shanghai (SH) (Ding *et al*., 2014, 2015) by utilising Greeno's (1998) situative theoretical perspective. Our research question is: in what way does Greeno (1998) model help to conceptualize the nature of the Chinese expert teacher's expertise in the LDS?

RESEARCH BACKGROUND

As pointed out by Pepin *et al.* (2017), the notion of 'expert teacher' is underpinned by the cultural values and different perceptions of the nature of teaching expertise. Whilst an individualistic, and primarily cognitive, perspective on teacher expertise privileges what might be deemed 'rational' factors of proficiency, a situative perspective (using Greeno's, 1998, situative theoretical perspective) might offer a more comprehensive view of the nature of the expertise of an expert teacher.

In research with teachers in China, Gu and Gu (2016) used the term 'teaching research specialist' (TRS) (*jiao yan yuan* in Chinese) to highlight the significant role of the TRS in improving in-service teacher professional development in China. Each TRS, em-

2018. In E. Bergqvist, M. Österholm, C. Granberg, & L. Sumpter (Eds.). *Proceedings of the 42nd Conference of the International Group for the Psychology of Mathematics Education* (Vol. 2, pp. 355-362). Umeå, Sweden: PME.

ployed in a specific school district in China, is a didactician in mathematics who works primarily with practicing teachers. While there are a number of studies of mathematics teachers' professional development in China in general, and the mentoring role of TRS in particular (see, for example, Gu & Gu, 2016; Pepin *et al*., 2016), little is known of the nature of the TRS's work in mentoring practicing teachers.

Two recent findings by Gu and Gu (2016) informed our aim to contribute to conceptualizing the complex nature of a TRS's expertise and the practice of the TRS in mentoring teachers in our LDS. First, Gu and Gu (2016) revealed that Chinese TRSs usually pay a great deal of attention to issues such as setting students' learning goals, designing instructional tasks, formative assessment of students' learning, and improving teachers' instructional behaviors. The TRSs generally pay less attention to mathematics (perhaps because the teachers generally have good mathematics knowledge) and less attention to general pedagogical issues. Second, the TRSs tend to address anticipated problems with a lesson, and with the subsequent lesson, based on their own previous experience. In doing so they may pay less attention to addressing issues raised by the teachers or engaging in dynamic dialogue with them.

The need to understand the interactions of cognitive, situational and social characteristics of the TRS expertise (as demonstrated by the expert teacher in our study) situated in the phenomenon that is the practice of TRS mentoring in China leads us to choose Greeno's (1998) situative perspective as our theoretical framework.

THEORETICAL FRAMEWORK

Greeno (1998) proposed that the main distinguishing characteristic of the situative perspective is its theoretical focus on interactive systems that are larger than the behavior and cognitive processes of an individual agent. One approach to this is to begin within the framework of individual cognition and work outward from the analyses of individual cognition. The alternative is to begin with the situative framework of interactional studies and work inward. In the study we are reporting in this paper, we apply the second approach. Figure 1 illustrates the situative model.

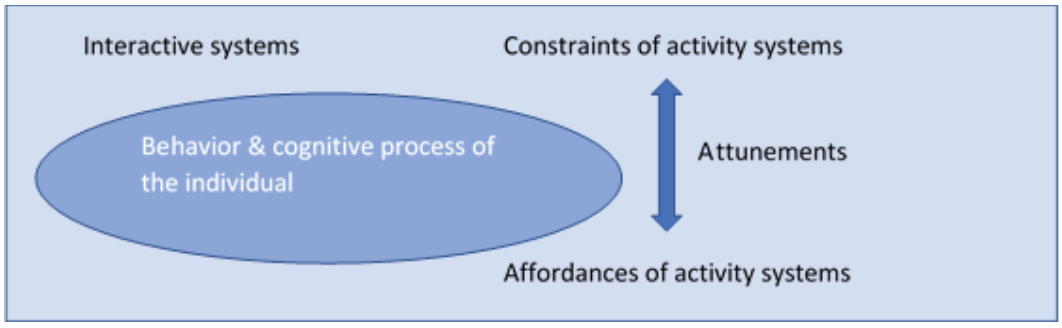

Figure 1: The situative model (adapted from Greeno, 1998).

In Greeno's (1998) framework, he uses the notion of *attunements* to *constraints* and *affordances*. Here *constraints* are the "if-then regularities of social practices and of interactions with material and informational systems that enable a person to anticipate

outcomes and to participate in trajectories of interaction", *affordances* are "qualities of systems that can support interactions and therefore present possible interactions for an individual to participate in"; and a person's *attunements* to constraints and to affordances are "regular patterns of an individual's participation" (Greeno's, 1998, p. 9). We use the situative model of the attunements to affordances and constraints of activity systems (as illustrated in Figure 1) in our data categories and analysis.

METHODOLOGY

Our school-based LDS was conducted in an international school located in the western suburb of Shanghai (for details see Ding *et al*., 2014, 2015). The process of our LDS model had three cycles. The first cycle (L1) was the teacher's initial lesson design, lesson implementation and reflection. The second cycle (L2) entailed implementation of the re-designed L1. The third cycle (L3) was the re-re-designed and re-re-implemented L1.

Each cycle included a set of the school-based teaching research group (TRG) activities, such as the teacher's classroom teaching, our study members' observation, and the mathematics TRG meetings. In our LDS there were seven elementary mathematics teachers and three national/regional educators and expert teachers (for more on our LDS project, see Ding *et al*., 2017). The expert teacher on which we report in this paper was, at the time of the research, a TRS who had worked in the city centre school district of Shanghai for over thirty years (for more on the nature of being an expert teacher in China and why we considered the term applies to two expert teachers in our LDS, see Ding *et al.*, 2017). We refer to the selected expert teacher as Mr Zhang, a pseudonym.

Our data sources include: the teacher's lesson plans, teaching notes and reflection diary; the transcripts of the video-recorded lessons; the transcripts of the video-recorded comments of Zhang in TRG meetings over the teaching cycles of the LDS model. The lesson topic was investigating the relationship between perimeter and area in the Shanghai Grade 3 textbook, and the lesson title was 'Which area is bigger?'. The central theme of the TRG meetings was on a participation-oriented lesson design; in Greeno's words (1998, p. 19), "not only what their students have come to know and understand, but also to how their students are currently able to participate in inquiry, discourse, and reasoning, and how they can help them advance to more successful participation".

In focusing on the expert teachers' expertise and mentoring activities in order to develop a framework to conceptualize an expert teacher's expertise in the LDS, here we focus on two main categories of the expert teacher's interactions in the TRG before and after the second cycle of the LDS: (1) redesigning the original lesson; and (2) implementation of the redesigned lesson. We apply Greeno's model (see Figure 1) to develop categories of the expert teacher's interactions in the LDS. We summarise selected examples in Table 1. Then, in Table 2, we further develop the sub-category of 'Interactive systems' according to Greeno's idea of *attunements* to *constraints* and *affordances*.

Sub-categories	Explanation	Examples of what was said by the expert teacher
Cognitive	e.g., Math knowledge in the textbook; pupil's conceptual understanding.	This textbook topic is not of learning a new concept, but a mathematical proposition.
Behaviour	e.g., Instructional procedure; Pupil's basic knowledge and skills.	*What's the intention of this sticks activity*? Putting sticks is related to a pupil's skill; *how would you embed the instructional intention into this activity*?
Interactive systems	e.g., The relations of individual learning with small group and a whole class discussions; pupils' interactions with materials, activities and teacher.	In terms of classroom discussion, we need to be aware of the fact that students' discussion is based on each individual's experiences and sense making of the activities.

Table 1: The categories of the expert teacher's interactions in LDS.

Sub-categories	Explanation	Examples of what was said by the expert teacher
Constraints	e.g., If-then regularities of a student's early experience of a classroom activity and of interactions with the tasks and other pupils to enable the student to anticipate outcomes and to participate in trajectories of interaction.	You need to know clearly about the relation of the following three lines: ① *what's students' previous experience with the putting sticks activity*; ② *what's the intention of this sticks activity?* … ③ the changes you made from a rectangle problem to a square problem; I wonder *whether these two learning situations were the best situation for students' learning*?
Affordances	e.g., Teacher's lesson design, together with activities and tasks design and knowledge connection.	I think that the lesson can be designed in a way to enable students to experience the whole process of plausible reasoning.
Attunements	e.g., The pattern of teacher's teaching instruments, questions and language to enable student to participate in learning.	*Why we chose this textbook topic to study? … Whether the lesson design suits our fundamental theory and main educational value nowadays?*

Table 2: The sub-categories of 'Interactive systems'.

CONCEPTUALIZING THE EXPERT TEACHER'S EXPERTISE

Coordinating multiple levels of analysis of Mr Zhang's expertise

We constructed the coding in Tables 3, 4 and 5 according to the categories in Tables 1 and 2. The coding in Table 3 focuses on the components of behaviour/cognitive (B/C), the coding in Table 4 on those of the interactive systems (IS) of Mr Zhang's expertise, and the coding in both Table 4 and Table 5 on the attunements to constraints and affordances.

First, the coding in Tables 3 and 4 show two levels of analysis of the dynamic interactional process of the expert teacher with the teachers in the LDS. As explained above, we started from the dynamic interactions in the TRG meetings and then worked inward to the parts in each teaching cycle (e.g., lesson design, lesson practice, teacher's reflection) in the LDS model in order to identify the codes in the general category of B/C at this stage of our data analysis. The term 'level' does not mean hierarchy in the analysis, but inward or outward layers of the analysis.

The coding in Table 3 captures the behaviour and cognitive components of both individual pupils and the teacher addressed in Zhang's explanations. For instance, the teacher and her pupils' ways to teach and learn the mathematics topic in the textbook.

Behaviour/ cognitive	**Explanation**	**Examples of what was said by Zhang**
Understanding textbook	e.g., Teacher's knowledge and skills of crafting textbook; pupils' conceptual understand of the textbook.	First, to understand the textbook. *Why we chose this topic to study?*
The type of mathematical proposition and its learning	e.g., Teacher's mathematics and pedagogy	It's not to learn a new concept, but to learn a new proposition. It's to discover a rule or a relationship in the process of learning the proposition.

Table 3: Codes of the behaviour and cognitive components in Zhang's explanations.

The coding in Table 4 recognizes Zhang's target to draw the junior teacher's awareness to the important interactions between mathematical proposition in elementary textbook and the assessment of teaching and learning. Data examples were chosen from Zhang's explanations to the junior teacher of redesigning L1 of the LDS (see Tables 3 as well).

Concurrently, the coding in Tables 3 and 4 can also be considered together in the analysis of the constraints of activity systems that were made visible by Zhang to the junior teacher in supporting the teacher to be aware of the factors that may play a role in the participation-oriented lesson design in the LDS. For instance, to enable pupils to participate actively in the mathematical practices and classroom discourse in the lesson, Zhang emphasised the interactions between a deep understanding of the teaching

and learning goal of the mathematic topic in the textbook and the assessment of teaching and learning, as illustrated by the example in Table 4.

Interactive systems	**Explanation**	**Example**
Assessment of teaching and learning	e.g., lesson structure and procedure; pupil's cognitive nature and their learning methods and processes; social and cultural values in education; etc.	Secondly, to distinct the deep learning from the surface teaching from the perspective of teaching and learning assessment. The deep learning addresses the cognitive process of students. The surface teaching refers to the teacher's instructional structure/procedure of the lesson that was advocated ten years ago. ... But it is very important for us to assess the lesson from students' learning perspective. That is, *whether the idea of the lesson design suits our fundamental theory and main educational value nowadays*?

Table 4: Codes of the interactive systems in Zhang's explanations.

The coding in Table 5 was identified for the level of analysis of the affordances of activity systems that were observed in Zhang's explanations in supporting the junior teacher's professional learning of how to implement the participation-oriented lesson design in the LDS. Data examples in Table 5 were chosen from Zhang's explanations to the junior teacher of re-implementing L2 of the LDS.

We consider that the types of Zhang's questions, such as '*what?*', '*how?*', '*why*?', '*whether*?' (we used *italic* to highlight them in the examples in Tables 1-5) play a significant role as a scaffolding of *attunements* for the junior teacher to be aware of, and then be able to participate in the trajectory of teaching and learning in the re-designed lesson that was explained by Zhang and then be able to reflect on her own instructional intentions and practice from this specific perspective.

The dual nature of Zhang's expertise in the LDS

From our analysis, we propose that there is a *dual nature* of Zhang's expertise in our LDS. On the one hand, Zhang's explanations with teachers in the TRG make the hidden constraints and affordances in the interactive systems of the LDS visible to teachers in order to engage pupils into actively participate and to be able to attune by themselves to the mathematical practices and classroom discourse in the designed lesson; on the other hand, Zhang's questions to teachers (see examples highlighted in Italic in Tables 3, 4 & 5) plays a kind of scaffolding role to enable the teacher to learn and understand how and why to attune to the constraints and affordances in the interactive systems of the LDS.

Affordances	**Explanation**	**Examples**
Lesson design	e.g., Mathematical inquiry lesson; lesson structure; instructional coherence.	There is an obvious gap in the first two activities in the lesson: The first activity is to draw rectangles with constant perimeter 10 cm. The second activity is to draw rectangles with constant perimeter 20 cm. You (the junior teacher) need to build up the connection of the two activities to support pupils to develop an understanding of the two activities. That is, *why the second activity is necessary after the first one?*
Teacher's teaching language	e.g., Teacher's explanation of teaching and learning goals of a classroom activity; teacher's questions, etc.	The rough thought and judgement of the first activity is that, given the same perimeter, the areas of rectangles can be different. The first activity is a stepping stone for the second activity. *Why?* The more precise judgement and finding of the regularity of the operation is from the second activity. That is, the closer the length and width of a rectangle, the larger the area. The teacher must play a leading role in explaining to pupils to enable them to participate in the coherence of the two activities.

Table 5: Codes of the affordances in Zhang's explanations.

DISCUSSION AND CONCLUSION

In this paper, we propose a conceptualization of the expert teacher's expertise in the LDS by coordinating the level of teacher and pupils' subject-based behaviour/-cognitive analysis (the two ellipses in Figure 2) and the level of the social-culturally situated analysis of the LDS from Greeno's model (1998). We propose that there is a dual nature of Zhang's expertise in our LDS, as indicated by the two overlapping rectangles in Figure 2.

The first nature of Zhang's expertise is scaffolding the teachers to learn concurrently the act of the multiple theoretical ideas (e.g., behaviour, cognitive and situative theories) through the participation-oriented mathematics lesson design study. The second nature of Zhang's expertise is scaffolding the teachers to learn to reflect on their own beliefs about the subject, pedagogical thinking and action, and to develop their identity as mathematics teachers in their long-term professional life.

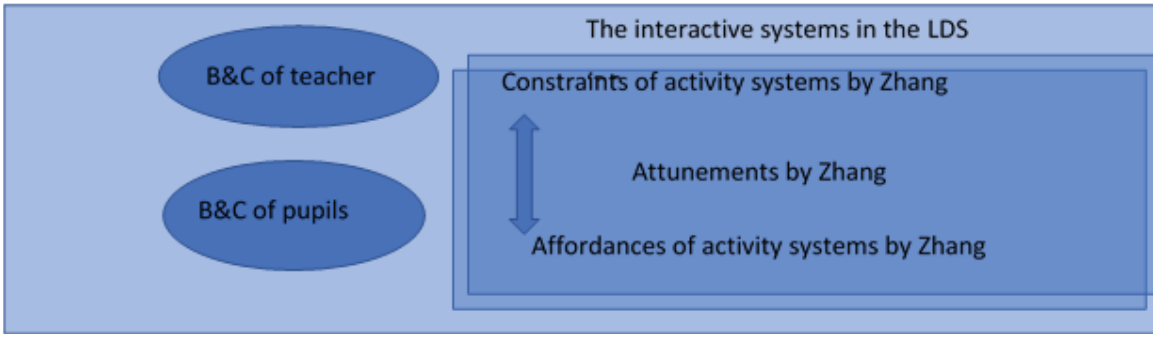

Figure 2: The model of the dual-nature of Zhang's expertise in the LDS.

In the next step, we plan to apply the categories and codes presented in this paper into a close analysis of the expert teacher's expertise. We also aim to make the scaffolding functions of Zhang's *attunements* in the LDS visible in our analysis. In so doing, we aim to contribute a deep analysis of the unique and significant functions of Chinese expert teacher's explanations and questions in the teacher professional development in China; something that outsiders may see as "monologues rather than dialogic in nature" (Gu & Gu, 2016, p. 451) that as such, remain a challenge to be explored by insiders to the education system in China.

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