Ding, L., Jones, K., Pepin, B., Sikko, S.A. (2014), How a primary mathematics teacher in Shanghai improved her lessons on 'angle measurement'. Proceedings of the 8th British Congress of Mathematics Education (BCME8), pp.113-120.

How a primary mathematics teacher in Shanghai improved her lessons on 'angle measurement'

Liping Ding, Keith Jones*, Birgit Pepin** and Svein Arne Sikko**
*Sør-Trøndelag University College, Norway and Shanghai Soong Ching Ling School, China; * University of Southampton, UK; ** Sør-Trøndelag University College, Norway*

We report on one component of a study of school-based teacher professional development (TPD) in Shanghai, China. Here we focus on an experienced primary teacher who is teaching the topic of angle measurement to 10 year-olds. Using data from the teacher's original lesson plans, her modified lesson plans, together with an expert teacher's advice and the teacher's reflections on her lesson design, we illustrate how the support of an expert teacher enabled the teacher to improve her instructional practice. This was by supporting her in thinking explicitly about the traditional classroom practice with which she was familiar and in building her 'wisdom of practice' within the context of instructional reform taking place in China.

Keywords: professional development, mathematics teaching in China, curriculum and pedagogy reforms, angle measurement

Introduction

In the 2012 PISA (Programme for International Student Assessment) study Shanghai-China (SH) has again the highest scores in mathematics, with a mean score of 613 points – the equivalent of nearly three years of schooling above the OECD average (OECD, 2013). As such, the ways in which mathematics teachers develop professionally in jurisdictions like Shanghai is of much interest. In China, the latest version of the National Mathematics Curriculum Standards (briefly called the Standards in this paper) encourages teachers in the country to develop teaching strategies to tackle the complex relationship between the teacher's leading role in the classroom and students' independent learning through classroom activities (Ministry of Education (MoE), 2011). Moreover, the Standards (MoE, 2011: 43) suggest that teachers "emphasise the implementation of the curriculum goals (e.g. students' basic knowledge and basic skills, mathematical thinking, problem solving, and interests and attitudes) as a whole through classroom mathematics activities." One of the most challenging issues for teachers in China is to adjust to this revised role and to implement the curriculum goals as a whole. There is an equivalent challenge for teacher educators and professional developers in supporting teachers as they update their knowledge and skills.

In this paper we report on one component of a school-based teacher professional development (TPD) study taking place in SH. Here we focus on a primary teacher as she works on how to improve the way she teaches the topic of angle measurement to her class of 10 year-olds. In this work the teacher is part of the school-based TPD community that includes researchers and an 'expert teacher', the latter being one of the leading primary classroom teaching research specialists from the city-centre school district in SH. Our research question focused on how the teacher utilised advice from the 'expert teacher' to improve her pedagogic thinking and instructional practice in her classroom.

The school-based coaching approach in teacher professional development

A range of recent research attempts to develop new insights into the effectiveness and impact of 'coaching' in school-based TPD. In the United States, for instance, Guskey and Yoon (2009) point out that the professional development efforts that brought improvements in student learning focused principally on ideas gained through the involvement of outside experts who presented ideas directly to teachers and then helped facilitate implementation. Furthermore, Obara (2010) highlights two aspects of coaching that are said to have positive impact on teachers' changes in their teaching practice: (1) being on-site and (2) encouraging collaboration and reflection. Nevertheless, while a teacher's beliefs about their classroom practice might undergo change as a result of the coaching process, Neuberger (2012) notes that such changes may not necessarily be stable. In Norway, Jaworski (2003) proposed another approach to teacher coaching, that of establishing a co-learning community. Jaworski is careful to distinguish between a community of inquiry and a community of practice, stating that in a community of inquiry "participants at all levels are learners" (p. 256). In the latter, what is learned can differ from one person to another, and can depend on the role a particular person might have, whereas in co-learning the learning of one participant is dependent on the participation and learning of other members of the co-learning community.

In the case of China, the experts' input is highly valued by teachers in a variety of forms of tschool-based TPD, such as apprenticeship practice (Huang, Peng, Wang and Li, 2010; Huang, Su and Xu, 2013); teacher research group (TRG) (Yang, 2009); and public lessons (Han and Paine, 2010). In view of the significant curriculum reforms taking place in China over recent years, Gu and Wang (2003) particularly highlight the critical role of experts in leading teachers to update theoretical ideas through what they term the 'Action Education' (AE) model ('Xingdong Jiaoyu' in Chinese). Here, 'experts' refers to university researchers, specialists in research on teaching (usually from the school district level), and expert teachers from inside and outside the school. In reporting on the effectiveness of such teacher/expert collaboration, Huang and Bao (2006: 292) quote a participating teacher's teaching diary as follows: "The advantages of collaborative lesson planning design are (1) to help me form an innovative teaching idea and (2) to find effective ways to handle difficulties by learning from other experienced teachers and experts".

Noticeably, in a review by East China Normal University of various Chinese TPD training programmes Yu (2009) reports that the AE model matches well the professional development needs of secondary 'backbone teachers' (who are excellent in teaching, for more see Han and Paine, 2010). However, little is known about the kinds of uncertainties ordinary school teachers may have during such a learning process, and of the kinds of teacher-expert interactions which may be effective in helping teachers to tackle such uncertainties. It is the expert teacher's direct interactions with the teacher in her learning process through the AE model that is the focus for this paper.

The study

Our school-based TPD study is being conducted in a laboratory school located in Qingpu district, a western suburb of SH (see also Ding, Jones and Pepin, 2013). The main project is a design-based experiment to study a particular model of professional development, akin to the AE approach by Gu and Wang (2003) that aims at

developing the teacher's professional knowledge by absorbing and building on the accumulated "wisdom of practice" (Shulman, 1986) through iterative cycles of teachers' lesson planning, implementation, post-lesson reflection and lesson re-implementation.

The participant groups of the study were: four researchers (the four authors), an expert teacher (Mr Zhang), two teachers (one in Grade 3 (G3) and the other in G4) each with more than ten years teaching experiences in primary mathematics at the time of the study and twelve mathematics teachers from the school's mathematics teacher group (from G1 to G6, ranging from newly-appointed teachers to teachers with about ten years teaching experience). In this paper we focus on the G4 teacher named Yanzi, a pseudonym.

We analysed Yanzi's teaching notes and lesson plans reflecting on her interactions with the expert teacher as a case study (Yin, 2013) of what an experienced teacher can learn from interacting with an expert teacher. The data collection strategies and sources included the following:

(1) Field notes:
- The major data source for this study was Yanzi's lesson plans and her teaching notes before and after Mr Zhang's interventions.
- Field notes of Mr Zhang's interventions in helping the teacher to overcome her uncertainties in planning lessons (also audio recordings of all the conversations).
- Teacher reflection notes about the 'lesson plan improvements'.

(2) Video- and audio-taped conversations and study meetings with Mr Zhang and the teacher/s and the researchers, before and after lessons; and the teacher's lessons.

In terms of data analysis, we focused on Yanzi's interactions with Mr Zhang, and her progress over the different stages of the first cycle of the study. As shown in Figure 1, the case teacher worked through the several stages of the first study cycle (June 2012 – July 2013).

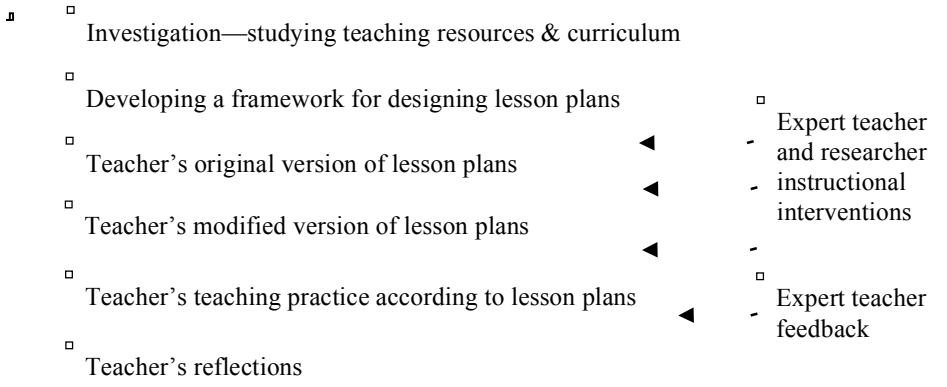

Figure 1. The first cycle of the study

During the first phase of our analysis, the first author examined all the available data across the stages of the study (see Figure 1), including relevant curriculum and textbook materials, teachers' initial lesson plans and improved lesson plans according to Mr Zhang's suggestions, transcribed lessons and meetings, field notes, and the teacher's written reflections. The first author then translated the key data from Chinese into English.

In analysing the data, following the AE model (Gu and Wang, 2003), as the research team we chiefly focused on Yanzi's self-reflection on her original lesson

plan and Mr Zhang's interventions that helped her to revise her lesson plan and implement it in classroom. We identified two preliminary coding categories to illustrate the main uncertainties Yanzi had, and the suggestions Mr Zhang provided to help Yanzi overcome her uncertainties and develop her pedagogic thinking and practice in her classroom: (1) 'teacher's uncertainty of planning an activity lesson'; (2) 'using worksheet in mathematics activity'. Subsequently, the preliminary categories were used to trace Yanzi's modifications (or not) in her pedagogic thinking in her reflection notes, lesson plans and lesson instruction practice according to Mr Zhang's interventions. In what follows we illustrate how Mr Zhang helped Yanzi to improve her pedagogic thinking and instruction practice through 'reflective lesson design'.

Findings

Yanzi initially designed a sequence of four lessons (each 35 minutes long) on the topic of angle measurement. The four lessons respectively focused on the 'concept of angle', 'angle classification', 'understanding the design of a protractor', 'using a protractor to measure angles'; these being the key content in the SH textbook. To trace the teacher's progress of pedagogic thinking and practice, together with Mr Zhang's interventions, here we focus on Yanzi's initial and revised lesson plans of the first lesson.

Overcoming the uncertainty of planning an activity lesson

In planning the first lesson, Yanzi took Mr Zhang's suggestion of using the activity of playing string puzzle (PSP), a popular game that young children like to play, to introduce the learning topic of angle to the students. The lesson plan was structured as follows:

1) *Introduction of problem context (IPC)*. Here, the activity of PSP was introduced to the class. Several key questions were highlighted in the lesson plan. For instance, can you play the string puzzle game? What figures do you find in the game? What is an angle according to your playing experience?
2) *Investigation of new knowledge (INK).* Three activities were planned here. Activity one was to lead the students to review the angle names such as obtuse, acute and right angles that they previously learned. Activity two was to guide students to count angles in different conditions. For instance, count angles when two lines are crossed, when two lines are crossed by the third line, when angles have a common point, and when angles have a common side. Activity three was to explore angle addition and subtraction.
3) *Consolidation by exercises (CE).* An immediate assessment of students' learning was intended by a set of routine exercises from the SH textbook.
4) *Conclusion (C).* Here, the question "What did you learn today?" was highlighted.

Mr Zhang's interaction with Yanzi to develop her pedagogic thinking about designing classroom activity is summarised in the following three key points:

1. To distinguish two types of learning experience in a mathematical activity: thinking and reasoning experience that is quite abstract and behavioural and operational experience that is concrete.
2. To use the '*Shen Tou*' method to construct purposefully various types of activities in a lesson, or across a sequence of lessons. This teaching method entails establishing a particular relationship between the teacher's purposeful

instruction and students' gradual learning progress, from being unfamiliar at the beginning to eventually acquiring particular skills or rough understandings of a method in certain area of mathematics (for details of Chinese expert teachers' use of the *Shen Tou* method see Ding, Jones and Zhang, 2014). In particular, the teacher should have a clear instructional consideration of what specific experiences students need in a specific activity for learning related concepts or methods later on.

3. To make a conclusion of the activities in order to enhance the representations of the concepts/experiences to be learned/gained.

Based on Mr Zhang's suggestions, Yanzi revised her first lesson plan as follows:

1) *Preparation activity*. The PSP activity was introduced to the class in a worksheet. In the worksheet, several tasks were listed. First, two pictures were given to students to observe and to compare (Figure 2). Students were asked to make the same pattern in the PSP activity and then to draw the angles they found in the patterns on the worksheet.
2) *Angle discovery activity*. Two activities were planned here. Activity one was to look for different types of angles (e.g., obtuse, acute and right angles), and activity two was to observe the relationships between angles (e.g. common point of angles, and common side of angles).
3) *Moving from experiences to exercises*. Students were expected to work on the paper-and-pencil exercises selected from textbooks according to the activities they had just played.
4) *Conclusion activity.* Teacher used drawings, symbols, letters, and words to make a summary of the representations of angles students conveyed across the previous two activities.

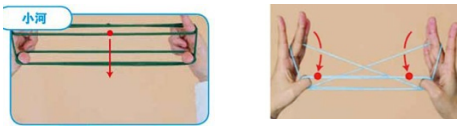

Figure 2. Two pictures of the playing string puzzle (PSP)

Using worksheet in mathematics activity

In her reflection notes, Yanzi had uncertainties about planning mathematics activity lessons:

> I was not able to develop concrete thinking of how to actualise the theoretical ideas of the activities in the classroom when I made the initial lesson plans. So the initial lesson plans could only be called plans of learning procedure. Teaching plan concerns about what teaching methods to be used and what kind of exercise and problems to enrich and to develop the learning process of students. Thus, teachers must consider the details of teaching such as teacher's questionings, hypothesising students' learning responses, what kind of knowledge foundation the teacher's question or the learning activity is based on, etc. So teaching plan is a guidance to enable teachers to have concrete ideas to conduct instruction. For instance, in the initial lesson plan of lesson one, the lesson structure (*IPC-INK-CE-C*) is a learning procedure I designed. … At that moment, I had not yet developed ideas about how to guide students to complete the learning procedure. I had little idea how to design the following aspects of the learning procedure. For example, 1) how to design the concrete activity? 2) how to design questions to guide students in activity? 3) how to design the exercises so to immediately gain students' learning feedback? (Yanzi's reflection note, 8 June 2013)

According to Mr Zhang's interactions with Yanzi, he guided Yanzi to develop her pedagogic thinking of organising mathematics activities in lessons by addressing in particular the following three strategies: (1) enable students to develop a broad understanding and 'free thinking' in the activities (not merely focus on understanding subject knowledge); (2) cultivate individual students' learning experiences as the core of teaching; and (3) use the '*Shen Tou*' teaching method.

Moreover, Yanzi conveyed the benefits she gained from Mr Zhang's constructive suggestions about the use of a worksheet in the activity instruction.

> In each activity, students were given a task worksheet. It's the first time for me to use it in my classroom instruction. In the traditional instruction, there are also learning tasks. However, the tasks are mostly stated for teachers to consider in the teaching plan, or they are explained in the teacher's oral guidance in the class. That is, the tasks are implicit in each step of learning. It is now the first time to make the tasks explicit in a worksheet. It would engage students in independent learning. In the traditional instruction, teachers often use tasks to gradually guide students to make gradual progress in learning. (Yanzi's reflection note, 8 June 2013)

Discussion and conclusion

In our study we are working towards building up a design framework to guide teachers to update their knowledge and develop flexible pedagogic thinking about teaching mathematics activities. In so doing, we aim to help teachers to enhance their teaching skills in order to be able to effectively implement important curriculum goals as a whole (see the list of the basic goals in the introduction section of the paper). In the process of building up our design framework, this paper points to the crucial role of the local expert teacher in helping teachers to overcome the gap between the teaching norms advocated in the reformed curriculum and teachers' daily-life practice in their classroom.

As shown in the foregoing session, Yanzi was uncertain about how to deal with two teaching 'norms' in her lesson plans: classroom activity and mathematical activity. That is, Yanzi's uncertainty was not about recognising students' active learning role in general classroom activities, but about how to deal with the complex relationship among three core elements in a classroom activity: students' independent learning role, teacher's teaching role and mathematics. Thus, Yanzi initially planned the teaching phases of the first lesson according to the traditional teaching norms like *IPC-INK-CE-C*. As demonstrated by Shao et al. (2013), in writing their lesson plans, teachers in China traditionally refer to what are called the Kairov five teaching phases (named after the Soviet educator since 1949). The teaching norms that characterise the five phases are: *organising teaching*; *reviewing learned knowledge*; *introducing new content*; *consolidation and summary*; *homework assignment* (p. 17). In our study, we introduced teaching norms according to our study of overseas textbooks (see Pepin and Haggarty 2001) for helping teachers to enable students to become independent in accumulating learning experiences in classroom activities: for instance, the norms of *Preparation activity*, *Independent discovery activity* and *Summary from activity experience* were deepened by studying foreign textbooks. We noted that while guiding the teacher to understand the new teaching norms of classroom activity, the expert teacher simultaneously made explicit to our case study teacher the careful use of the traditional teaching method (e.g. *Shen Tou*) to develop students' basic knowledge and skills in mathematics activity. Such findings lead us to argue that it is crucial to make explicit the mathematics pedagogy that teachers traditionally

appreciate and practice within the context of instructional reform, in order to deepen teachers' understandings of ways to develop classroom pedagogy and improve student learning.

Moreover, Yanzi confessed that she was unclear about how to organise mathematics activities in her initial plan: for instance, she had questions about which teaching methods to use in designing an activity lesson; which questions to be asked; which exercises to be chosen and prepared/arranged; and what the students' existing knowledge and thinking related to the mathematics topic to be learned might be. To assist Yanzi in revising her lesson plans, Mr Zhang explained to Yanzi how to organise three mathematics activities in the lesson with concrete examples of teacher's questions and exercises. To help Yanzi to develop her teaching strategy of using one game (the PSP in the first lesson plan) across the three mathematics activities, Mr Zhang constructively guided Yanzi to use the worksheets with a list of learning tasks to enable students to develop independent learning through these activities. Mr Zhang also drew the teachers' attention to the possible use of various types of representations to enrich students' learning of mathematics concepts/experiences embedded in the activities. Noticeably, Mr Zhang applied considerable theoretical ideas both from general teaching-learning theory and the specific theory of mathematics pedagogy. Yet, Mr Zhang stated that he "can guide teachers to conduct mathematics activities teaching in their classes, but (he has) very vague ideas of the theory that underlie (his) instruction/advice to teachers". In developing a well-designed TPD study, the challenge we now face is to develop a deeper understanding of the local theories held by expert teachers, both in terms of their thinking and theoretical constructs, as well as of their practices.

For Yanzi, this paper shows how the support of an expert teacher enabled her to improve her instructional practice by supporting her in thinking explicitly about the traditional classroom practice with which she was familiar and in building her 'wisdom of practice' within the context of instructional reform taking place in China.

Acknowledgement

We thank Shanghai Soong Ching Ling School and Shanghai Education Science Research Council who funded this task and instruction design project.

References

Ding, L., Jones, K. and Zhang, D. (2014) Teaching Geometrical Theorems in Grade 8 using the 'Shen Tou' Method: A Case Study in Shanghai. In Fan, L., Wong, N.Y., Cai, J. & Li, Sh. (Eds.) *How Chinese Teach Mathematics: Perspectives from insiders*. Singapore: World Scientific.

Ding, L., Jones, K. & Pepin, B. (2013) Task design through a school-based professional development programme. *Proceedings of the ICMI study 22: Task design in mathematics education*. Oxford: University of Oxford.

Gu, L. & Wang, J. (2003) Teachers' development through education action—the use of 'Keli' as a means in the research of teacher education model. *Curriculum, Textbook & Pedagogy*, 2003, *Vol. I*, 9-15; *Vol. II*, 14-19. [顾泠沅，王洁。教师在教育行动中成长—以课例为载体的教师教育模式研究. *课程 - 教材 - 教法*, 2003, *第一期*, 9－15；*第二期*, 14-19.]

Guskey, T.R. & Yoon, K.S. (2009) What works in professional development, *Phi Delta Kappan*, 90(7), 495–501.

Han, X. & Paine, L. (2010) Teaching mathematics as deliberate practice through public lessons. *The Elementary School Journal*, 110(4), 519-541.

Huang, R., Su, H. & Xu, S. (2013) Developing teachers' and teaching researchers' professional competence in mathematics through Chinese Lesson Study. *ZDM: The International Journal on Mathematics Education.*

Huang, R., Peng, S., Wang, L. & Li, Y. (2010) Secondary mathematics teacher professional development in China. In Leung, F.K.S. & Li, Y. (Eds.) *Reforms and Issues in school mathematics in East Asia* (pp. 129-152). Rotterdam: Sense.

Huang, R. & Bao, J. (2006) Towards a model for teacher professional development in China: Introducing Keli. *Journal of Mathematics Teacher Education,* 9, 279-298.

Jaworski, B. (2003) Research practice into/influencing mathematics teaching and learning development: Towards a theoretical framework based on co-learning partnerships. *Educational Studies in Mathematics*, 54(2-3), 249-282.

Ministry of Education, China, P.R. (Ed.) (2011) *Mathematics Curriculum Standards of Compulsory Education.* The 2011 Version. Beijing: Beijing Normal University.

Neuberger, J. (2012) Benefits of a teacher and coach collaboration: A case study. *Journal of Mathematical Behavior*, 31(2), 290–311.

Obara, S. (2010) Mathematics coaching: A new kind of professional development. *Teacher Development*, 14, 241-251.

OECD (2013) *PISA 2012 Results: What 15-year-olds know and what they can do with what they know*. Paris: OECD.

Pepin, B. & Haggarty, L. (2001) Mathematics textbooks and their use in English, French and German classrooms: a way to understand teaching and learning cultures, *ZDM: The International Journal on Mathematics Education*, 33 (5), 158-75.

Shao, G., Fan, Y., Huang, R., Ding, Er., & Li, Y. (2013) Mathematics classroom instruction in China viewed from a historical perspective. In Li, Y. & Huang, R. (Eds.) *How Chinese Teach Mathematics and Improve Teaching*. New York: Routledge.

Shulman, L.S. (1986) Those who understand: Knowledge growth in teaching. *Educational Researcher*, 15(2), 4-14.

Yang, Y. (2009) How a Chinese teacher improved classroom teaching in teaching research group: a case study on Pythagoras theorem teaching in Shanghai. *ZDM Mathematics Educati*on, 41, 279-296.

Yin, R.K. (2013) *Case Study Research: Designs and methods* (5th edn.) Thousand Oaks, CA: Sage

Yu, P. (2009) A review of research on Chinese mathematics teacher professional development in the last three decades. *Shuxue Tongbao*, 48(7), 11-14. [喻平。中国数学教师专业发展研究三十年的回顾。*数学通报*，*第48卷*，第7期，11/14页]