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The Approaches of Developing Teachers' Expertise in Mathematics Instruction in Taiwan

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The motivation for studying on Taiwanese teachers' expertise of mathematics instruction derives in part from the findings emerging from TIMSS, PISA, and TEDS-M which show that school students or future teachers in Taiwan surpassed the score of international average. The curriculum that prescribes the mathematics content to be learned is an importance factor affecting student achievement. It may be argued that more important factor is the teachers who deliver the content. Students' mathematics achievement is an indicator of effective instruction and an effect of teachers' mathematics knowledge (Hill, Rowan, & Ball, 2005). The growing interest in examining school mathematics curriculum, high quality of classroom instruction, and teacher preparation in an international context is closely related to students' mathematics achievement between Asian countries and its counterparts (Leung & Li, 2010; Li & Kaiser, 2011; Tatto, Schwille, Senk, Ingvarson, Peck, & Rowley, 2008). For example, Leung and Li's book stresses on the policies and practices of curriculum and teachers education of the countries in East Asia, while Li and Kaiser's book focuses on the identification and examination of teacher expertise in mathematics instruction in selected educational systems between the East and West. TEDS-M study uses the concept of opportunity to learn as central to explain the impact of teacher preparation programs on teacher learning in international contexts (Tatto, et al., 2008). These books provide a platform for sharing and understanding the reform efforts in teacher education from selected high-achieving countries in East Asia. It is important for the rest of world to learn what is happening while improving students' learning. Much remains to be understood about the ways and what cultural resources are utilized to shape the quality of mathematics instruction for improving students' mathematics achievement. The Research Forum is an opportunity for Taiwan to share the approaches and practices that are employed to develop teacher expertise in mathematics instruction.

The paper does not focus on the nature of teacher expertise of mathematics instruction valued in different education systems; instead, it concentrates on the approaches of developing teacher expertise in mathematics instruction valued in Taiwan. Prior to the development of teacher expertise, what constitutes teacher expertise valued in Taiwan needs to be briefly discussed. The paper begins with a brief description on the nature of teacher expertise in mathematics instruction in Taiwan. It is followed by the development of teacher expertise in mathematics instruction.

Nature of Teacher Expertise in Mathematics Instruction Valued in Taiwan

There is no universal agreement on what counts as an expert teacher or teacher expertise in mathematics instruction, while there are similarities and differences on the contents of teachers' expertise between Eastern and Western. Possible differences across countries in the East can be even found in classroom contexts. For instance, expert teacher in Korea has the characteristics of mathematics instruction such as posing questions that further challenge and extend students' activity or mathematical thinking; re-stating in detail or insisted on clear explanation to the student

such that the whole class examined the crucial contents; encouraging students to present their methods; and leading students to be actively participated in activities (Pang, 2008). The expertise displayed in mathematics instruction in Taiwan contains at least ten features (Lin & Li, 2011). The expert teachers are skilled in: (1) creating and using tasks with high-level cognitive demands and realistic context for evoking multiple solutions and eliciting the anticipated solutions; (2) sequencing the problems to be posed based on students' learning; (3) predicting students' anticipated solutions; (4) sequencing students' multiple solutions for class discussion based on conceptual development; (5) asking various questions for different purposes; (6) asking key questions in time and asking follow-up questions; (7) interpreting students' productions; (8) highlighting and summarizing the main point at the end of the discussion; (9) transiting from one activity to another corresponding to students' learning; (10) creating specific problems for assessing students understanding and as a part of preparation for the next lesson (Lin & Li, 2011). These ten elements of teacher expertise are further clustered into three categories by phases of instruction: (1) prior to teaching, expert teachers master in designing and using tasks that support rich mathematics thinking; (2) during teaching, they purposely selecting and sequencing students' solutions for whole class discussion; critically questioning and using students' errors or misconceptions for discussion; responding to students' questions adequately, and summing up main points at the end of a lesson; and (3) after teaching, expert teachers skill in creating creative assignments for assessing what and how students learned in the lessons.

Approaches of developing Teacher Expertise

An attempt to helping a novice teacher becoming an expert teacher is commonly enterprise for teacher educators in different educational systems across countries. Various approaches have been developed and used in pursing high-quality mathematics instruction in different education systems in East Asia, such as lesson study as an approach for the teachers in Japan (Yoshida, 2008); exemplary lesson for China (Huang & Bao, 2006), and instructional contests for Korea (Pang, 2008); master teachers for Taiwan (Lin, 2008). There is a common feature among these countries that research on teacher development is based on a view of the teacher as an adult learner whose development results from changes in cognitive structure. The research on teacher development indicates that teachers in teacher professional programs may be different development stages and have very different needs for assistance. Berliner (1989) theorizes that teachers progress through five stages in the journey toward expertise: novice, advanced beginner, competent, proficient, and expert. It implies that: (1) a teacher progressing to be an expert teacher is long process; (2) a teacher in different development stages needs different assistance. Thus, to be an expert, a teacher needs assistances from various approaches.

The various approaches and cultural resources utilized in Taiwan for assisting teachers developing their expertise include: (1) using textbook accompanying with teacher guides is an approach of helping teachers toward reform-centered instruction; (2) taking the instructional competition at local or national level; (3) lesson study weekly on Wednesday afternoon in nationally wide; (4) master teachers of mathematics instruction in each local area; (5) upgrading

teachers' academic degree; and (6) teachers' participation of teacher professional development programs. Due to the limitation of the paper page, teachers' participation in a longitudinal study of teacher development program as an approach for developing teacher expertise is the focus of the paper.

This program has been continually funded by the National Science Council since 1997 and the majority of the participating teachers have been accredited as master teachers in mathematics instruction by outside evaluators. There are six in-service teachers that are recruited from the same grade level to participate in the program each year. They are recruited from the same grade if possible, since the same grade level lends similar contents readily as a base of discussion. The number of participating teachers in each year is not limited to less than 8, in order to maintain each participant with adequate time for discussing in professional meetings.

Upon completing the recruitment, several meetings about lesson study are conducted. The lesson study meetings are structured as: before teaching, the instructor to be observed requires accurate identification of teaching objectives, deep analysis of student difficulties in understanding the concepts, read critically the materials in textbook on the basis of students' learning, and it is followed by conducting pretest for understanding prior knowledge and what difficulties students have before teaching the lesson. Afterwards, they require restructure and redesign the activities of the lesson and write a brief lesson plan in accordance with students' hypothetical learning trajectory. All participating teachers' lessons were scheduled to be observed in turn. In particular, these teachers were scheduled to sit altogether in a classroom to observe a lesson and immediately have a follow-up intensive meeting.

During teaching, the students were divided into groups of 5 to 6. Each participant teacher sits next to students in a group, as the purpose of each student to be observed deeply. The observation is not intended to demonstrate excellent teaching to others rather readily make a focus for the follow-up professional discussion. We do not regularly encourage the instructor to be observed to treat this observation as a demonstration of an exemplary lesson; instead, the observation is expected to be a normal teaching. The classroom observation is the distinguished feature of the teacher professional program from the demonstration of an exemplary lesson engaging in other teacher development in nation-wide. The observers helping the instructor glean the multiple solutions students coming up the lesson. The instructor' selection and sequence of multiple solutions presented in the lesson are likely to be brought up to the follow-up discussion.

After teaching, the instructor are asked to synthesize and reflect on his/her own teaching and the rest of the participants are invited to articulate what they observed in the lesson with respect to the tasks, students' responses, teacher questioning. Teacher educators in the program in play different roles: facilitators, supporters, and coordinators. The discussion is regularly wrapped with the framework of the mathematics topic in the lesson, the ideas to be used in the following lesson, the issues to be put in the written cases of teaching, and the items of an assignment for assessing what students learned in the lesson. These activities are used to support participating teachers to improve the quality of mathematics instruction.

In sum, teachers shape and refine their expertise in mathematics instruction through their participation in a longitudinal professional development program, because they have the opportunity to reflect for lesson prior teaching, reflect in teaching, and reflection on lesson after teaching. These reflections are sourced for/from a classroom observation instead of a classroom demonstration which is the purpose for polishing teaching competences and skills. Thus, their expertise of mathematics instruction are improved gradually.

Reference

Berliner, D. C. (1989). Implications of studies of expertise in pedagogy for teacher education and evaluation. In Educational Testing Service (ED.), *New directions for teacher assessment: Proceedings of the 1988 ETS invitational conference* (pp.39-67). Princeton, NJ: Educational Testing Service.

Hill, H. C., Rowan, B., & Ball, D. L. (2005). Effects of teachers' mathematical knowledge for teaching on student achievement. *American Educational Research Journal, 42*(2), 371–406.

Huang, R., & Bao, J. (2006). Towards a model for teacher professional development in China: Introducing Keli. *Journal of Mathematics Teacher Education, 9*, 279–298. doi:10.1007/s10857-006-9002-z.

Leung, F. & Li, Y. (2010.). *Reforms and issues in school mathematics in East Asian: Sharing and understanding mathematics education policies and practices.* Sense publisher.

Li, Y. & Kaiser, G. (2011). *Expertise in mathematics instruction: An international perspective*. New York: Springer.

Lin, P. J. (2008). Pursuing excellence in mathematics classroom instruction to meet curriculum reform in Taiwan. *Proceedings of the 32th Conference of the International Group for the Psychology of Mathematics Education,* Vol.1. (pp.167-172, Research Fora). July 17-22. Mexico, Morelia, Michoacan University of Saint Nicholas of Hidalgo.

Lin, P. J., Li, Y. P. (2011). Expertise of mathematics teaching valued in Taiwanese classroom. In Y. Li, & G. Kaiser (Eds.), *Expertise in mathematics instruction: An international perspective* (pp.263-291). New York: Springer.

Lin, P.J. & Li, Y.P. (2009). Searching for good mathematics instruction at primary school level valued in Taiwan. *ZDM-The International Journal of Mathematics Education*. 41(3), 363-378.

Pang, J. S. (2008). Good mathematics instruction and its development in South Korea. In O. Figueras, J. L. Cortina, S. Alatorre, T. Rojano, & A. Sepu´lveda (Eds.), *Proceedings of the joint meeting of 32nd annual conference of the International Group for the Psychology of Mathematics Education and the 30th of the North American chapter, (Vol. 1, pp. 173–178).* Mexico: Michoacan University of Saint Nicholas of Hidalgo.

Shimizu, Y. (2008). Exploring indispensable elements of mathematics instruction to be excellent: A Japanese perspective. In O. Figueras, J. L. Cortina, S. Alatorre, T. Rojano, & A.

SepulvedaSearching for good mathematics instruction at primary school level 377 (Eds.), *Proceedings of the joint meeting of 32nd annual conference of the International Group for the Psychology of Mathematics Education and the 30th of the North American chapter, (Vol.1, pp.161–166)*. Mexico: Michoacan University of Saint Nicholas of Hidalgo.

Tatto, M. T., Schwille, J., Senk, S. L., Ingvarson, L., Peck, R., &Rowley, G. (2008). *Teacher education and development study in mathematics (TEDS-M): Policy, practice, and readiness to teach primary and secondary mathematics. Conceptual framework.* East Lansing, MI: Teacher Education and Development Study-Mathematics International Study Center, College of Education, Michigan State University.