

Lin, P. J. (2008). Pursuing excellence in mathematics classroom instruction to meet curriculum reform in Taiwan. *Proceedings of the 32<sup>th</sup> 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.

## **PURSUING EXCELLENCE IN MATHEMATICS CLASSROOM INSTRUCTION TO MEET CURRICULUM REFORM IN TAIWAN**

Pi-Jen Lin

National Hsinchu University of Education, Taiwan

### **INTRODUCTION**

Much has been written about the fact that Asian students show superior performance in international mathematics assessments compared with their non-Asian counterparts, such as PISA, TIMSS 2003 (Mullis, Martin, Gonzalez, & Chrostowski, 2004; OECD, 2003). Students' performance can be taken as a possible indicator of the effectiveness of instruction. Stigler and Hiebert's (1999) analysis of the TIMSS video study collected from Japan, America, and Germany indicates that students in Japan spent more time inventing mathematical concepts while students in the United States spent more time on routine practice (Stigler, Gallimore, & Hiebert, 2000). A similar pattern is found regarding mathematics concepts that were developed by "the teacher with students' participation" (77% in Japan and 22% in the United States) vs. simply "stated by the teacher" (23% in Japan and 78% in the United States) (Stigler and Hiebert, 1999). Results suggest that there are cultural differences between Asian and Western countries in expectation for student achievement in mathematics and instructional strategies.

### **LEARNER-CENTERED APPROACH EMPHASIZED IN CURRICULUM**

Instruction involved in a complex process is shaped by the interaction of teachers and curriculum materials. The implementation of curriculum materials varies considerably as teachers make different interpretations. Engagement with particular curricular features can impact teachers' pedagogical understanding, and then shape mathematics instruction (Remillard & Bryans, 2004). This suggests that various instruction approaches are driven by different curricular reforms. For instance, teacher-oriented instruction emphasized in the Curriculum Standards of Elementary Mathematics (CSEM) issued in 1975 is much different from learner-oriented approach emphasized in the CSEM reissued in 1993 (Ministry of Education, 1993). Traditionally, most teachers begin teaching with the textbook and teacher's guide from the beginning of each semester, following it lesson by lesson. The teachers' focus is helping students passing a quiz after another. Most teachers characterize a most effective teaching as offering well-organized teacher-directed instructions. As a result, memory and drilled practice are emphasized, while important mathematics education goals such as meaningful understanding of concepts and the skills of communicating, problem solving, reasoning, and connecting tend to be overlooked.

Conversely, the philosophy underpinning the 1993 version reflects that

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knowledge should be constructed actively rather than passively. Learning mathematics is viewed as an integrated set of intellectual tools for making sense of mathematical situations instead of as accumulating facts and procedures. Mathematics classrooms are expected to become as mathematical communities instead of classroom as simply a collection of individuals. The right answer is verified by logic and mathematical evidence, instead of being determined by the teacher. Effective teaching includes that teachers know how to ask critical questions and plan lessons that reveal students' prior knowledge, teachers create mathematics tasks and analyze student learning in order to make ongoing instructional decisions, and teachers stimulate classroom discourse so that the student are clear about what is being learned. The roles of teachers are shifted into a problem-poser and a facilitator from a problem-solver and a knowledge constructor. Students become the problem-solver and knowledge constructor instead of a knowledge copier.

In order for the implementation of learner-centered curriculum to be successful, teachers need to be committed to the vision of the reform and to be more versatile in using instructional strategies to facilitate students' mathematical power. Therefore, to move the reform ahead, various strategies, techniques, and activities are developed in different professional development programs of Taiwan. For instance, a training master teacher program supported by the MOE since year 2003 aims in training teachers to be masters in mathematical instruction toward learner-centered approach. Fifty teachers participating in the program each year are recruited from different school districts distributed in different areas. They receive a series of institutes or workshops at the beginning and the end of school semester. The rationale of curriculum is the preliminary courses of the workshops. It is followed by the courses related to mathematical instruction and assessment. During the school year, they are assisted in classroom practices by a pool of teacher educators from different universities. The teachers to be master teachers are asked to teach a lesson for teachers who are not participating in the program to learn to teach effectively. There are about 6-10 master teachers in each county as a pool of consultants for school teachers to improve their mathematics teaching. They are frequently invited by schools to deliver a lecture, to write textbooks, and to do professional work with respect to mathematics instruction. Their professional work can be an indicator of the effect of the training master teacher program.

One of the development programs supported by the National Science Council supporting teachers in developing teachers' high quality of instruction has been run for ten years. The goals of the teacher education program include 1) enhancing the rethinking of mathematics teaching in classrooms; 2) fostering teachers' awareness of children's learning; 3) supporting teachers as they begin to put into practice their new

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vision of a learner-centered approach to teaching mathematics. Social constructivism dealing with the construction of knowledge through interactions between humans and social worlds is drawn on as the basis for the professional program. Each year, a collaborative school-based professional team consisting of a teacher educator and 6 to 8 primary school teachers from a school or across schools is set up for providing teachers with professional dialogues based on classroom practices. Reflection, social interaction, and cognitive conflict are considered as three mechanisms of improving teachers' teaching. Mathematics classrooms and school-based professional team are two social contexts for teachers supported mutually in the teacher education program. Various strategies for improving teachers' understanding of students' learning including assessment integrated with instruction, analysis of students' various solutions, and the use of teaching cases were inquired in the studies (Lin, 2002, 2005, 2006). Within the space constrains of this paper, I mainly focus on the design of high cognitive demand of tasks as a kernel part of teaching a lesson, as one of the features of learner-centered approach, since it plays an important role in student learning.

## **MAINTAINING HIGH LEVEL COGNITIVE DEMAND TASKS AS A FEATURE OF GOOD TEACHING**

Different tasks require different levels of student thinking. The cognitive demands of tasks can be changed during a lesson. Starting with a high-level task does not guarantee student engagement at a high-level. Thus, teachers participating in the professional program need support to maintain high level cognitive demands at the implementation stage. T1, a sixth grade teacher, is one of the teachers involved in the development program. The nature of high-level cognitive demands she maintains in teaching a lesson relevant to ordering fractions is displayed here as an example.

Before this lesson, students have learned ordering fractions with like denominator fractions. In the lesson including setup phase and implementation phase, T1 gave students four pairs of fractions to decide which is greater. The four pairs ( $\frac{1}{5}$  vs.  $\frac{1}{7}$ ,  $\frac{5}{16}$  vs.  $\frac{5}{9}$ ,  $\frac{4}{9}$  vs.  $\frac{8}{12}$ ,  $\frac{11}{12}$  vs.  $\frac{14}{15}$ ) have four basic types: unit fractions, fractions with like numerator or denominator, and fractions with unlike numerators and denominators.

The setup phase includes T1's communication to her students regarding how they were expected to decide which of the fractions is greater and how they were expected to compare them. The four pairs of fractions identified as the cognitive demands at the level of "procedure with connection" were based on the following three reasons: (1) The four pairs of fractions develop mathematical understanding; (2) T1 purposely changed the tasks with different types of fraction from the textbook for developing students' multiple strategies. (3) T1 intentionally designed the numerals of numerator and denominator between two fractions for developing students' various strategies rather than relying on the algorithm.

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The implementation phase starts as soon as students began to work on the task and continued until T1 and students turned their attentions to a new task. Five different strategies were used by the TI's students for the four problems. Students used two strategies to compare  $\frac{1}{5}$  vs.  $\frac{1}{7}$ . One is referred to unit fraction. They realized that there is an inverse relation between the number of parts into which the whole is divided and the resulting size of each part, so that  $\frac{1}{5} > \frac{1}{7}$ . It was then followed by the problem "comparing  $\frac{5}{16}$  vs.  $\frac{5}{9}$ ". Students still used two previous strategies, partitioning and finding a same denominator. They also developed a new strategy by finding a referent point ( $\frac{1}{2}$  or 1). TI attempted to reduce the use of common denominator, since the product of  $16 \times 5$  is too big to getting correct answer. TI expected students to learn various strategies and each strategy can be applied in a suitable situation.

Moving on to the third problem "Order  $\frac{4}{9}$  vs.  $\frac{8}{12}$ ", students focused only on the numerator or only on the denominator and as a result made incorrect conclusions. T1 encouraged students solved successfully the problem by either using reference point  $\frac{1}{2}$ , or finding a common denominator requires finding  $\frac{4 \times 4}{9 \times 4}$  equivalent to  $\frac{4}{9}$  and  $\frac{8 \times 3}{12 \times 3}$  equivalent to  $\frac{8}{12}$  with the like denominator 36 or finding the same numerator 4 requires finding  $\frac{4}{6}$  equivalent to  $\frac{8}{12}$  and then ordering  $\frac{4}{6}$  and  $\frac{4}{9}$ , or finding the same numerator 8 requires finding  $\frac{8}{18}$  equivalent to  $\frac{4}{9}$  and then ordering  $\frac{8}{18}$  and  $\frac{8}{12}$ .

During the implementation phase, both T1 and her students were viewed as important contributors to how tasks were carried out. T1 questioning to students or asking follow-up questions was relied on what her students worked on the task. The ways and extent to which T1 supported students' thinking was a crucial ingredient of maintaining high-level tasks at the level of procedure with connections. These tasks evolved during the lesson involved multiple strategies, required an explanation, and connected procedures to meaning. Part of the lesson shown in a 5-minute video will be presented in the Research Forum.

## REMARKS

Maintaining high quality of cognitive demand of tasks is orchestrated by the teachers participating in a teacher professional program for pursuing excellence in mathematics classroom teaching to meet the innovation of curriculum. The features of excellent mathematics teaching to be achieved are characterized as contextual problems to be posed, multiple representations for a given problem, coherence and progression from one activity to next, students' problem solving to be encouraged, students' various solutions and explanations to be articulated. However, learner-centered focusing on students' speaking mathematics does not constitute the mainstream of mathematics classrooms in Taiwan. The learner-centered approach recommended in CSEM is successfully implemented in highly low percentage of

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mathematics classrooms. The teaching of instructor-centered whole class organization in Taiwanese mathematics classroom is strongly supported by the international TIMSS 2003 study (Mullis, et al. 2004). The learner-centered approach recommended in the curriculum is not popularly implemented into classrooms is based on the following possible reasons. First, it is a challenge work for teachers who are used to teach with a teacher-centered approach. Second, it is not supported by the mathematicians who are concerns with mathematics teaching. Third, the learner-centered approach replaced by instructor-centered approach is not coherently recommended in the newly curriculum.

## REFERENCES

- Lin, P. J. (2002). On enhancing teachers' knowledge by constructing cases in classrooms. *Journal of Mathematics Teacher Education*. Vol. 5, Issue 4. 317-349.
- Lin, P. J. (2005). Supporting teachers' learning to teach mathematics in primary teacher professional development program. In Linda Barnes (Ed.), *Contemporary Teaching and Teacher Issues (175-196)*. NY: Nova Science publisher.
- Lin, P. J. (2006). Conceptualizing teachers' understanding of students' mathematical learning by using assessment tasks. *International Journal of Mathematics and Science Education*. 4(4),545-580 .
- Martin, M. O., Mullis, I. V. S., and Chrostowski, S. J. (2004) .*TIMSS 2003 Technical Report : Findings From IEA's Trends in International Mathematics and Science Study at the Fourth and Eighth Grades*. Chestnut Hill, MA: TIMSS International Study Center, Boston College.
- Ministry of Education (1993). *Curriculum standards for elementary mathematics*. Taiwan: Taipei.
- Mullis, I. V. S., Martin, K. D., Gonzalez, E. J., & Chrostowski, S. J. (2004). *TIMSS 2003 International mathematics report: Findings from IEA's trends in international mathematics and science study at the fourth and eight grades (Eds.)*. Chestnut Hill, MA: TIMSS International Study Center, Boston College.
- Organization for Economic Co-operation and Development (2003). *The PISA 2003 assessment framework-mathematics, reading, science, and problem solving knowledge and skills*. Paris: Author.
- Remillard, J. T. (2004). Curriculum materials as tools: A sociocultural analysis of teachers' use of curriculum: Paper presented at the annual meeting of the *American Educational Research Association*, San Diego, CA.
- Stigler, J. W., Gallimore, R., & Hiebert, J. (2000). Using video surveys to compare classrooms and teaching across cultures: Examples and lessons from the TIMSS Video Studies. *Educational Psychologist*, 35, 87-100.
- Stigler, J. W., & Hiebert, J. (1999). *The teaching gap: Best ideas from the world's teachers*

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(pp.167-172, Research Fora). July 17-22. Mexico, Morelia, Michoacan University of Saint Nicholas of Hidalgo.  
*for improving education in the classroom*. New York: Free Press.