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The same tasks, different learning opportunities: An analysis of two exemplary lessons in China and the U.S. from a perspective of variation

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ABSTRACT

This study examined the learning opportunities afforded in two exemplary lessons based on a theory of variation. Implemented in China and the U.S., the two lessons focused on the same topic of patterns in a calendar and were carefully developed through a lesson study approach. Both lessons set similar learning goals but enacted these goals differently. When compared with the U.S. lesson, the Chinese lesson provided more learning opportunities through high cognitively demanding tasks focusing on different identities within patterns. However, the U.S. lesson, which featured fewer tasks and focused on a single pattern identity, may have better supported students in discerning the critical features within the objects of learning. The implications for task design and implementation for effective mathematics teaching are discussed.

1. Introduction

Classroom comparisons have recently been used as an effective method for identifying plausible ways to improve teaching and student learning in mathematics (e.g., Clarke, Keitel, & Shimizu, 2006; Hiebert et al., 2003; Li & Shimizu, 2009). Despite the success of Shanghai China students on the Programme for International Students Assessments (Organization for Economic Co-operation and Development [OECD], 2009, 2012), there has been a lack of such studies involving mathematics classrooms in China. Moreover, China and the U.S. have made great efforts to implement reform-oriented curricula in classrooms in the last decade (Common Core State Standards Initiative [CCSSI], 2010; Ministry of Education [MOE], 2001, 2011; National Council of Teachers of Mathematics [NCTM], 2000, 2014). Given the substantial differences between these two countries regarding cultural beliefs about teaching and learning mathematics (Cai & Wang, 2010; Li, 2011), comparing the ways of teaching the same topic in China and the U.S. will deepen mathematics educators' understanding of mathematics instruction.

Traditionally, Chinese classes have been described as large and teacher dominated, with students who are well-disciplined, passive learners (Leung, 2005; Stevenson & Lee, 1995). Classroom teaching in China is fluent and coherent (Chen & Li, 2010), with a focus on the development of important content, problem solving, and proving (Leung, 2005). In contrast, studies on mathematics instruction in the U.S. have revealed an emphasis on procedural knowledge, with less attention to rigorous mathematics, problem solving, and proving (Jacobs et al., 2006; Wood, Shin, & Doan, 2006). Such classrooms are not aligned with the recommendations associated with reform curricula. Although there have been substantial

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mathematics curriculum reforms in both China and the U.S. (CCSSI, 2010; MOE, 2001, 2011; NCTM, 2000), little is known about what really happens in reform-oriented classes in these countries. Thus, this study intentionally focused on lessons deliberately developed as being representative of reform-oriented lessons. Specifically, based on the same pre-made lesson plan, one Chinese lesson study group and one U.S. lesson study group developed exemplary lessons on *exploring patterns embedded in calendars*.

Recognizing that effective implementation of cognitively demanding tasks that promote students' sense making and problem solving is crucial for students' learning (Stein, Engle, Smith, & Hughes, 2008), this study was designed to explore how strategically adapting and implementing tasks could create different learning opportunities, as revealed from the perspective of a theory of variation that focuses on recognizing the necessary conditions for learning (Marton & Pang, 2006; Marton & Tsui, 2004). By comparing the lessons enacted in the two classes, this study examined how a lesson could maximize students' learning opportunities through creating appropriate patterns of variation. The significance of this study lies in its examination of the potential a theory of variation holds for supporting the identification of effective strategies for designing instruction and implementing high cognitively demanding tasks that promote student sense making and problem solving, thus supporting reform efforts in both countries.

2. Background of the study

This review of relevant literature includes three key aspects. First, we summarize the studies on mathematics instruction in China and the U.S. Second, the main ideas of effective mathematics instruction recommended in reform documents are synthesized. Third, a theory of variation that guides this study is discussed. Following these sections, a framework for the current study is described.

2.1. Mathematics instruction in China and the U.S.

Beyond the general description of Chinese classrooms such as large classroom size, well-disciplined students, and polished and coherent teaching (Chen & Li, 2010; Stevenson & Lee, 1995), the main features of Chinese mathematics teaching have been summarized as follows: lecturing and explaining dominated in the form of a whole classroom instruction; explaining and illustrating the new topic carefully; unfolding the lesson coherently; emphasizing mathematical reasoning, knowledge construction, and development; having a high demand in mathematics content; emphasizing internal mathematics connections among problems and variation exercises; and summarizing key points in due course (e.g., Huang & Li, 2009; Huang, Mok, & Leung, 2006; Leung, 2005). In particular, Chinese instruction features teaching with systematic variations of problems that are applied not only to form and consolidate new concepts and procedures but also to master knowledge and develop students' abilities in problem solving. These features have been argued as representing an effective mathematics teaching practice (Gu, Huang, & Marton, 2004; Huang, Mok, & Leung, 2006).

In contrast, studies on U.S. mathematics classes have normally provided negative descriptions. For example, comparing TIMSS 1995 and TIMSS 1999 video studies, Jacobs et al. (2006) revealed three key points regarding U.S. classes. First, approximately three-fourths of classroom time is used for repeatedly solving procedural and low complexity problems. Second, there are few opportunities to discuss multiple solutions. Third, the majority of problems are repeated, corresponding to a lack of mathematical connections. In addition, Wood, Shin, and Doan (2006) reported that although the U.S. teachers in their study explicitly stated their intention to incorporate reform notions such as group activities, balancing concepts, problem solving, and skills, the behaviors in their classes did not reflect these ideas appropriately. Instead, the U.S. teachers maintained traditional teaching strategies with a focus on repeated symbolic operations, rather than conceptual understanding, mathematical reasoning, and mathematical thinking. Similarly, Silver, Mesa, Morris, Star, and Benken (2009) found that although the U.S. teachers in their study provided a variety of topics in their lessons, the topics themselves lacked cognitive challenge. According to these researchers, even though the tasks required students to do hands-on activities or connect the mathematics to daily life situations, there were seldom opportunities for students to explain and reason. The documents submitted by these teachers that were intended to demonstrate the best practices in mathematics teaching did not support students' engagement in high cognitively demanding tasks. Thus, taken collectively these studies demonstrate that U.S. classrooms typically reflect traditional teaching methods, rather than implementing reform-oriented instructional practices.

2.2. Intended mathematics instruction in China and the U.S.

In China, the newly released national mathematics standards (MOE, 2011) suggested that teaching is a process in which teachers and students actively engage, interact, and co-develop. Based on contextual situations, mathematics teaching should: establish students' self-exploration in problem solving; guide students in obtaining basic knowledge, basic skills, basic thinking methods, and basic activity experiences through practicing, thinking, exploring, and communicating; enhance students' active learning; and continually develop students' abilities in forming, posing, analyzing, and solving problems. During class, teachers should appropriately deal with the relationship between telling and self-exploration, to enlighten students' active thinking, while serving as an organizer, guide, and collaborator.

In the U.S., NCTM standards (2000) suggested that effective mathematics teaching requires instruction that builds on what students know, challenging and supporting their learning. To meet this expectation, teachers must have a deep