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# Learning to teach high school mathematics: Patterns of growth in understanding right triangle trigonometry during lesson plan study

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**Abstract**

"Lesson plan study" (LPS), adapted from the Japanese Lesson Study method of professional development, is a sequence of activities designed to engage prospective teachers in broadening and deepening their understanding of school mathematics and teaching strategies. LPS occurs over 5 weeks on the same lesson topic and includes four opportunities to revisit one's own ideas and the ideas of others. In this paper, we describe one prospective teacher's growth in understanding right triangle trigonometry as she participated in LPS. This study is part of a much larger study investigating how prospective secondary teachers learn to teach mathematics within the context of LPS. Results of this study indicate that Image Saying, an activity for growth in understanding from the Pirie–Kieren model [Pirie, S., & Kieren, T. (1994). Growth in mathematical understanding: How can we characterize it and how can we represent it? *Educational Studies in Mathematics*, *26*, 165–190], is critical to prospective teachers' growth in understanding school mathematics. Multiple opportunities and contexts within which to share understanding of school mathematics led to significant growth in understanding of right triangle trigonometry which in turn led to growth in understanding of teaching strategies. That is, the results of this study indicate that growth in understanding school mathematics (what to teach) leads to growth in understanding teaching strategies (how to teach) as prospective teachers participate in LPS.


*Keywords:* Lesson study; Teacher preparation; Growth in mathematical understanding; Trigonometry; Proportional reasoning

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## 1. Introduction

*I prefer this method of teaching because it was the way that I was taught.*

(Molly (pseudonym), prospective middle school mathematics teacher, Spring 2001).

Molly's statement captures one of the biggest challenges for mathematics teacher educators today (Bowers & Doerr, 2001; Hill, 2000; Ma, 1999; Nicol, 1999). The challenge of preparing teachers to teach in ways they were never taught, however, is not simply limited to the task of changing prospective teachers' beliefs about the nature of teaching mathematics. Rather, it necessarily entails the task of challenging and extending prospective teachers' ideas about school mathematics (the mathematics they will teach). In fact, the Conference Board of Mathematical Sciences (2001) asserted,

> . . .there is evidence of a vicious cycle in which too many prospective teachers enter college with insufficient understanding of school mathematics, have little college instruction focused on the mathematics they will teach, and then enter their classrooms inadequately prepared to teach mathematics to the following generations of students (p. 5).

Due to this perpetual cycle of inadequate knowledge of school mathematics, the Conference Board of Mathematical Sciences strongly recommended that K-12 teacher preparation programs revise their programs of study to provide better preparation for future teachers in both university mathematics (typical college mathematics courses) and school mathematics. As such, this study was conducted to investigate the mathematical and pedagogical products of an experimental curriculum used as part of an introductory methods course for prospective secondary mathematics teachers.

### *1.1. Mathematical knowledge for teaching*

Shulman (1986) delineated subject specific knowledge for teaching into three categories: subject matter content knowledge, pedagogical content knowledge, and curricular knowledge. Subject matter content knowledge refers to the facts, concepts and underlying structure of the content whereas pedagogical content knowledge refers to "the ways of representing and formulating the subject that make it comprehensible to others" (1986, p. 9). Understanding common student misconceptions and strategies for challenging such misconceptions are examples of pedagogical content knowledge. Curricular knowledge, the third category for subject specific teacher knowledge, refers to the curriculum and its associated materials. Such categorization was the catalyst of many studies aimed at understanding the development of mathematical content knowledge (Ball, 1990; Berenson et al., 1997; Borko et al., 1992; Sherman, 1992; Simon, 1993) and pedagogical content knowledge (Ball, 1988; Blanton, Berenson, & Norwood, 2001; Eisenhart et al., 1993; Simon & Schifter, 1993) for prospective mathematics teachers.

Content knowledge research (Ball, 1990; Berenson et al., 1997; Borko et al., 1992; Sherman, 1992; Simon, 1993) revealed that prospective teachers are quite often limited to a procedural understanding of school mathematics. Ball's (1990) work illustrated the difficulty that many prospective teachers have with division of fractions (fragmented and procedural understandings), whereas Borko et al.'s (1992) work indicated that prospective teachers have difficulty teaching division for understanding when they have not been given opportunities to reconsider their knowledge of school mathematics. Simon (1993) found many prospective elementary teachers' mathematical knowledge of division to be procedural. In