

Repeated Field Teaching: Preservice Teachers' Changes in Teaching Efficacy and Theories of Mathematics Teaching

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Abstract. The aim of this study was to understand preservice teachers' changes in their perceived teaching efficacy and theories of mathematics teaching by repeated field-teaching. A mathematics (teaching) methods course was designed to include repeated field-teaching with multiple supports, including course instructors, school teachers, peers, and a course website. The course website was used to organize all course reading materials, discussion, work submission, and research data collection. Compared with that after first field-teaching, the preservice teachers' teaching efficacy increased after the second field-teaching in pedagogy-content coordination, fluent teaching process, effective solution to student difficulties, and problem posing. In addition, their theories of effective mathematics teaching changed from teacher-centered, theoretical, and procedural approaches to student-centered, practical, and thematic ones.

Keywords: Mathematics teaching; teacher education; teaching efficacy; theories of teaching

1 Introduction

Providing preservice teachers with authentic teaching experiences is one of the major purposes of a teacher preparation program. A mathematics (teaching) methods course can serve this purpose in that it provides preservice teachers with opportunities to have an overview of teaching materials and methods for a specific school subject, e.g., mathematics, to put their theories of teaching into practice, and to reflect on their own teaching (Lee & Wu, 2006). Only presentation of learning or teaching materials cannot guarantee the enhancement of teacher professional development (Collopy, 2003). A teaching practicum curricular design with multiple sources of high-quality human and electronic supports, comprehensive aims, sufficient time, and careful sequences can increase the possibility that preservice teachers have desirable and successful learning experiences (Beswick, 2006; Ryan, Toohey, & Hughes, 1996; Wu & Lee, 1999, 2004). Most teaching practicum courses, however, give preservice teachers few opportunities and supports to make improvements after their reflection on their teaching. Reflection on teaching is an essential ability for preservice teachers to become professional teachers but repeated teaching and further reflections with multiple supports are likely to boost preservice teachers' teaching efficacy and to elaborate their theories of effective teaching.

Development of teaching efficacy and sound theories of effective teaching is an essential aim of preservice teacher education and a mathematics methods course. Teaching efficacy is related to the accomplishment of effective teaching, which in turn influences the quality of learning environments and the achievements of their students. Teaching efficacy is also related to teacher expertise, persistence, enthusiasm, commitment, low anxiety, and well-being for a life-long career as a teacher (Bandura, 1993, 1994, 2004; Liu, Jack, & Chiu, 2007; Smith, 1996; Swars, 2005; Swars, Daane, & Giesen, 2006; Tschannen-Moran & Hoy, 2001; Ware & Kitsantas, 2007). Continuous construction of theories on effective teaching is not only a sign of reflective teaching but also a measure to promote professional development and to facilitate communication among teachers because there is a diversity of theories on teaching among teachers (Chiu, 2009; Lloyd, 1999). Research has indicated that a course focusing on student-centered, active, sensing, hands-on, minds-on, and inquiry-event learning experiences for preservice teachers can increase their achievement, conceptual understanding, interest, and self-efficacy, and outcome expectancy beliefs (Avard, 2009; Bleicher & Lindgren, 2005; Eshach, 2003; Huinker & Madison, 1997). The objective of this study, therefore, was to enhance preservice teachers' teaching

efficacy and their theories of effective mathematics teaching by a mathematics methods course focusing on student-centered design and repeated teaching in real classroom settings with multiple sources of supports for face-to-face and on-line dialogue and reflection.

1.1 Enhancing Teaching Efficacy through Repeated Field-Teaching with Multiple Supports

Self-efficacy is personal judgments of one's capacity to succeed in managing one's functioning in a particular situation given the concern of one's abilities and the situation (Benight & Bandura, 2004). Teaching efficacy is mainly influenced by authentic teaching experiences and interaction with significant others in preservice teachers' learning environments, e.g., supervisors, instructors, peers, school teachers, and their students (Charalambous, Philippou, & Kyriakides, 2008). Without essential support from multiple sources, teacher efficacy is very likely to decline especially during the full field-teaching period (Plourde, 2002; Hoy & Spero, 2005). As such, providing preservice teachers with essential, comprehensive and multi-source support is a necessary practice in a mathematics methods course focusing on field-teaching.

Repeated field-teaching with multiple supports from significant others is likely to create more opportunities for the enhancement of self-efficacy than one-time field-teaching. We can view repeated field-teaching as a form of mastery learning for preservice teachers to have a higher chance of successful learning experiences in complex and difficult teaching situations. Mastery learning is especially useful when students working on difficult tasks in that it increases opportunities to succeed and to give student mastery experiences, which in turn are related to an increase in self-efficacy and positive attitudes towards learning (Guskey & Gates, 1986; Kulik, Kulik, & Bangert-Drowns, 1990). From the perspective of cognitive approaches to learning, mastery learning can help store newly developed pedagogical knowledge and skills into long-term memory. Based on the perspective of behavioral approaches to learning, mastery learning is a form of practice, which can increase the association between stimuli (e.g., classroom settings and student questions) and responses (e.g., lesson plans and teacher answers).

There is, however, a different voice from Slavin (1987; Slavin & Karweit, 1984), who aimed to verify that it was team work rather than mastery learning that increased student achievements. As such, we can be more certain that support and feedback from multiple sources, e.g., peers and teachers, in a formative manner is an essential component of a mastery learning program for promoting reflection, improvement, and achievement (Bloom, 1987). For this study, it appears to be important to provide preservice teachers with multiple sources of support during repeated field-teaching in order to increase their mastery experiences and self-efficacy.

1.2 Enhancing Theories of Mathematics Teaching through Repeated Field-Teaching with Multiple Supports

Preservice teachers' prior knowledge about mathematics teaching is likely to be one directly adopted from textbooks or lectures in relation to pedagogy, given their few experiences of teaching. Constructivist approaches to mathematics teaching suggest that solving authentic problems and reflecting on problem-solving processes are effective activities for preservice teachers to change their conceptions about the nature of mathematics teaching (Steele & Widman, 1997). A science methods course that focuses on social-constructivist and reflective assessment strategies successfully enhanced students' conceptual changes in relation to inquiry teaching (Wang & Lin, 2008). As such, we can expect that a mathematics methods course focusing on field-teaching can provide preservice teachers with an authentic learning situation, which will facilitate their construction of theories on effective teaching. Repeated field-teaching is likely to give opportunities for further reflection and further construction of their theories.

Research has also found that both face-to-face and online discussions can serve the purpose to construct the conception of learning once students' approaches to learning are taken into account (Ellis, Goodyear, Calvo, & Prosser, 2008). Authentic learning experiences are related to deep approaches to learning (Biggs, 2001). As such, we can expect that preservice teachers' theories on effective teaching are likely to be enhanced by a mathematics methods course focusing on authentic, student-centered, and

reflective field-teaching especially with multiple sources of human and electronic supports.

1.3 Hypothesis

1. The preservice teachers' teaching efficacy will be enhanced through repeated field-teaching with multiple supports.
2. The preservice teachers' theories of effective mathematics teaching will be enhanced through repeated field-teaching with multiple supports.

2 Method

2.1 Sample

Eighteen preservice teachers, who registered for the Teaching Practicum for Primary Mathematics (TPPM) course, participated in this study. The participants were primary-education majors in their third year of study.

2.2 Procedures

The TPPM course was conducted by an instructor and an experienced teacher, who was the course teaching assistant, through three phases: (1) overview of the literature on mathematics teaching contents and methods and the design of lesson plans (eight weeks), (2) first field-teaching for a class (four weeks), and (3) second (repeated) field-teaching for another class (four weeks). The course took around four months, from late February to late June in 2009. There was no textbook for the course; instead, all reading materials in relation to mathematics teaching contents and methods were obtained from multiple sources, including the course instructor, the teaching assistant, books, research papers, and the Internet. The reading materials were all placed on the course website (a Moodle system). The topics of the reading materials included the meaning of doing mathematics, mathematics curriculum, planning effective mathematics teaching, mathematics teaching methods, cognitive processes and mathematics learning, understanding-centered mathematics teaching, problem-solving centered mathematics teaching, affective issues in learning mathematics, assessment for mathematics learning, and teaching methods for sub-topics of mathematics, e.g., algebra, measurement, and geometry.

In the first phase for overview and design, the preservice teachers read the reading materials for discussion in class; they also had to design their lessons. The preservice teachers were grouped into eight groups, each with two or three people. Group members worked together to design their lesson plans and conduct their field-teaching. Each group had to upload their initial designs onto the course website for discussion in class and online dialogue. Prior to their two phases for field-teaching, all groups had to submit their designs to the class teachers whose classes the preservice teachers were going to conduct their field-teaching for comments, suggestions, and discussions. The field-teaching was conducted in a primary school in Taipei, Taiwan. The school had two classes for each grades. The preservice teachers also had to upload their final lesson designs and handouts onto the course website for a final review from the course instructor.

In the second phase for the first field-teaching, the preservice teachers taught a particular class based on their lesson plans for four weeks. Each of the eight groups of preservice teachers taught a class of either Grade 2, 3, 4, or 5. In other words, every two groups of preservice teachers taught different classes of the same grade.

In the third phase for the second field-teaching, the preservice teachers taught a class of the same grade as that in their first field-teaching. For instance, if a group of preservice teachers taught a grade-4 class in the first field-teaching, they taught another grade-4 class in the second field-teaching. The preservice teachers were encouraged to use lesson plans similar to those they used in the first field-teaching. They were also encouraged to make a necessary revision of the lesson plans based on their experiences from their first field-teaching and to adapt their lesson plans to the new class in the second first filed-teaching. Their lesson plans also had to be reviewed by class teachers and by the course instructor.

In each week, all the eight lessons of field-teaching were conducted in different classes at the same time. The eight lessons were discussed in class immediately after their file-teaching so that the preservice teachers could know what happened in other classes, learn from their peers' teaching, and increase the opportunity for reflective teaching. For the second filed teaching, the preservice teachers also are asked to share their comparison between their first and second field-teaching including changes in lesson plans, teaching processes, and student responses in class. The aim of this comparison was to make salient their awareness of the differences between their first and second field-teaching.

2.3 Data Collection

Data were collected from multiple sources. For the on-line dialogue on the course website, each group had a group area for discussion and to share their group works, e.g., lesson plans and handouts. In addition, each of the preservice teachers had a personal area on the course website to share their personal ideas anytime. In the face-to-face periods, all discussions were accompanied with information that they posted on the course website if there were any and their field-teaching video records, photos, and work samples. All the face-to-face teaching and discussion periods were audio recorded with the PowerCam software. For the two field-teaching phases, at least one field-teaching lesson was video recorded and the other lessons were taken photos each week.

2.4 Tools

The preservice teachers filled in an on-line questionnaire in relation to their teaching efficacy after their first and second field-teaching, respectively. The questionnaire had seven six-point (1 = strongly disagree ~ 6 = strongly agree) Likert-scale items (Table 1). The seven items asked preservice teachers to provide their judgment of their capacities to perform desirable teaching behaviors in their filed-teaching. The seven items were in relation to their pedagogical content knowledge, process management, adaptation to student differences, and communication with students, which all were important teaching capacities (Guo & Chang, 2004; Hogan, Rabinowitz, & Craven, 2003; O'Donnell, Reeve, & Smith, 2007).

Table 1. Preservice teachers' rating on their teaching efficacy after their first and second filed-teaching

Items	1st field-teaching		2nd field-teaching		F		η^2
	M	SD	M	SD			
I master subject content knowledge.	4.71	.92	4.94	.83	1.36		.08
I can apply teaching methods suitable for teaching contents.	4.29	.69	4.76	.75	5.89	*	.27
I have a fluent and systematic teaching process.	4.12	.93	4.82	.88	11.76	**	.42
I can engage student through teaching activities.	4.35	.86	4.65	.70	2.47		.13
My teaching design successfully link to student experiences.	4.06	.75	4.35	.61	2.04		.11
I can understand and deal with student difficulties properly.	3.94	.83	4.88	.60	12.72	**	.44
I have proper skills for asking and answering questions and pose problems at different levels.	3.82	.95	4.65	.86	17.62	***	.52

Note: N = 17. One preservice teacher did not complete the questionnaire. * $p < .05$; ** $p < .01$; *** $p < .001$. Small effect size: $.01 < \eta^2 < .06$; medium effect size: $.06 < \eta^2 < .14$; large effect size: $\eta^2 > .14$ (Cohen, 1988, p. 283).

The preservice teachers were also asked to post their theories of effective mathematics teaching in both figures and words several times throughout the progress of the course whenever there was a change in their theories to their personal areas on the course website. They were required to submit at least one theory before their second field-teaching and one at the end of the course, i.e., after their second field-teaching. Their theories posted on the course website were open to others in the course and were shared in the face-to-face periods from time to time. The preservice teachers also submitted onto the course website a three-page term essay regarding comparisons between their first and second field-teaching, how to become an effective mathematics-teacher, and how their theories of effective mathematics teaching changed over time.

3 Results

3.1 Changes in Preservice Teachers’ Teaching Efficacy

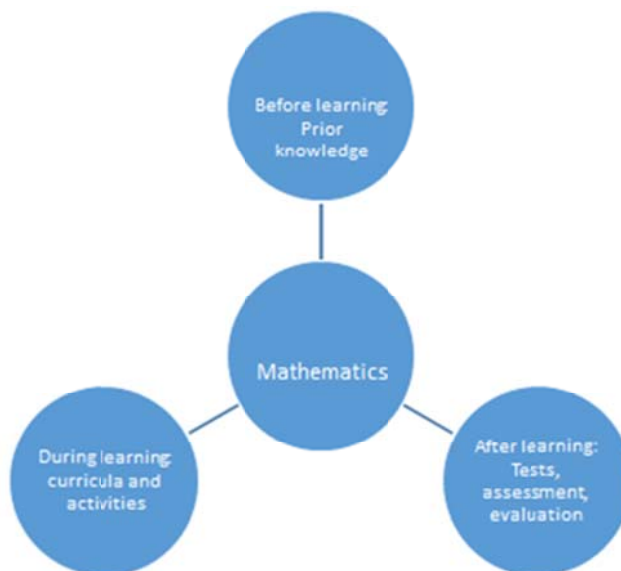
A doubly multivariate repeated measures model was used to analyze the quantitative data in relation to teaching efficacy collected through the on-line questionnaire. The test results for within-subjects effects revealed that there were differences in the teaching efficacy of the preservice teachers between the first and second field-teaching (Wilks' Lambda = .25, F = 4.31, p = .019) and the difference could not be ignored because of a large effect size (partial eta squared, $\eta^2 = .75$). Table 1 shows that student mean scores on all the seven items increased from the first to second field-teaching and significant increases occurred on four items (Items 2, 3, 6, and 7).

3.2 Changes in Preservice Teachers’ Theories of Effective Mathematics Teaching

Out of the 18 preservice teachers, 17 used both figures and words to describe their theories of effective mathematics teaching: Two of them created four theories of effective mathematics teaching, three created three theories, and the others created two theories during the process of the course. One preservice teacher used only words to describe her theories. The following analysis will focus on the 17 preservice teachers’ works that included both figures and words to describe their theories of effective mathematics teaching. A cross-case analysis based on the method of constant comparison was used to categorize the patterns of changes in the preservice teachers’ theories (Glaser & Strauss, 1967; Miles & Huberman, 1994). The changes that the 17 preservice teachers made in their theories of effective mathematics teaching could be categorized into three patterns.

From More Teacher- to More Student-Centered Approaches. Seven out of the 17 preservice teachers’ theories of effective mathematics teaching changed from more teacher- to more student-centered approaches. They based their theories more on what teachers did and thought as the authority in class in their initial theories and then more on what students did and thought as learners in mathematics classrooms. Figure 1 shows a student’s first and final theories that reveal this pattern of changes.

A. First theory



B. Final theory

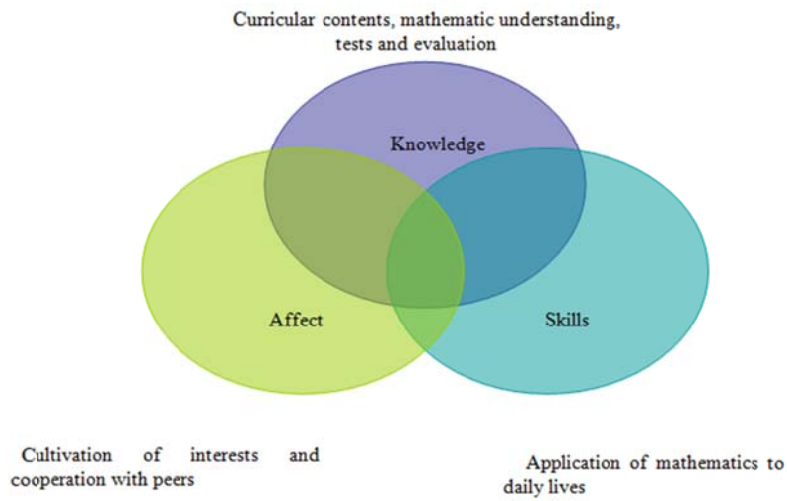
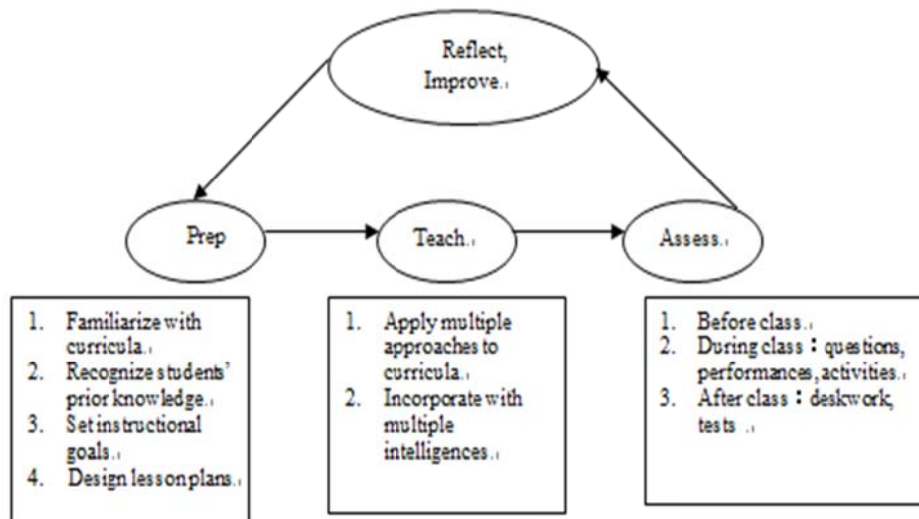


Figure 1. An example of the pattern of changes in preservice teachers’ theories of effective mathematics teaching from more teacher- to more student-centered approaches.

From More Theoretical to More Practical Approaches. Six preservice teachers had a narrower scope of coverage in their initial theories, normally based on the perspective of a teacher. They gradually had a broader scope, which incorporated the perspectives of other teachers, school authorities, parents, and students. Figure 2 presents an example showing this pattern of changes.

A. First theory



B. Final theory

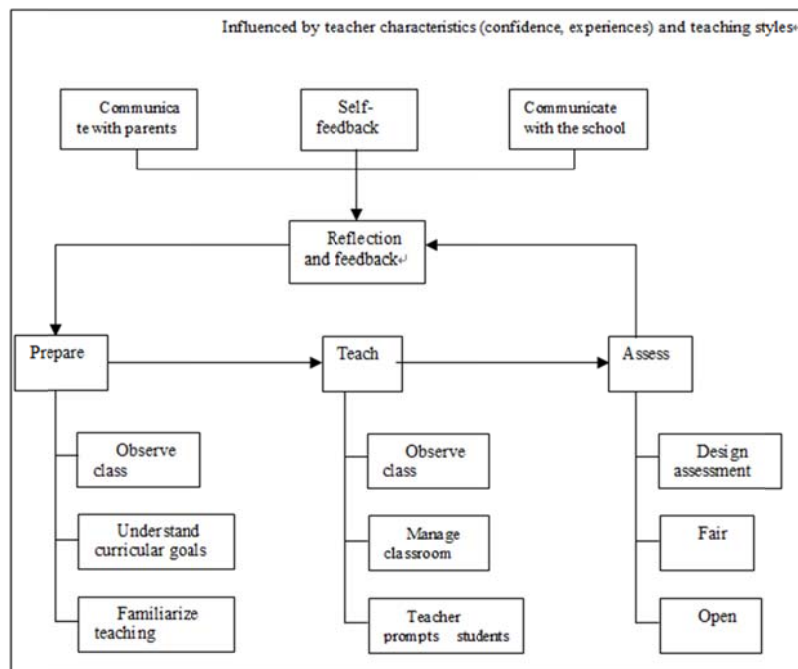
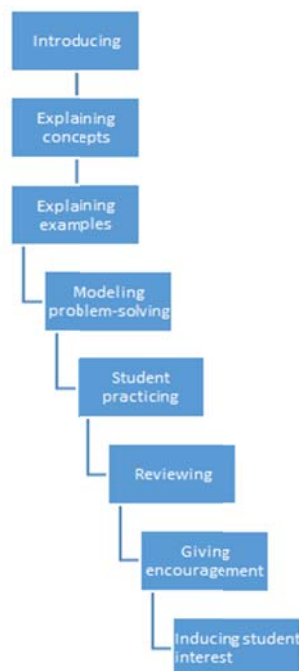


Figure 2. An example of the pattern of changes in preservice teachers’ theories of effective mathematics teaching from more theoretical to more practical approaches.

From More Procedural to More Thematic Approaches. Four preservice teachers at first focused on detailed procedures for teaching a lesson and then gradually discovered a theme of effective mathematics teaching. Figure 3 presents an example of this pattern of changes.

A. First theory



B. Final theory

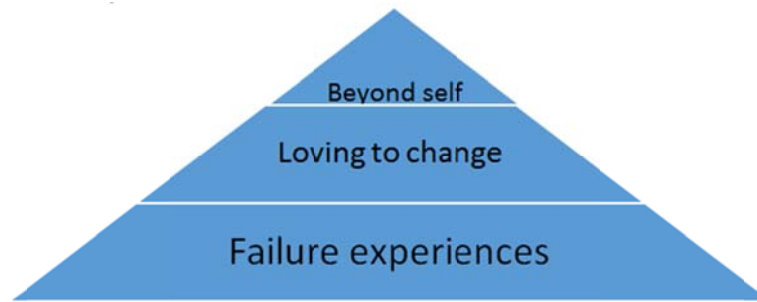


Figure 3. An example of the pattern of changes in preservice teachers' theories of effective mathematics teaching from more procedural to more thematic approaches.

4 Discussion

This study attempted to increase preservice teachers' teaching efficacy and to deepen their own theories of effective mathematics teaching through the use of repeated field-teaching in a mathematics methods course with support from multiple human and electronic sources. Three characteristics are identified in relation to how the course may benefit the preservice teachers in terms of enhancing their teaching efficacy and theories of effective mathematics teaching: (1) opportunities to re-adapt the same teaching contents to different classes, (2) opportunities to create and improve their theories on teaching, and (3) opportunities for reflection based on multiple sources of support and feedback from course instructors, class teachers, and peers through face-to-face and on-line dialogue. The enhancement of the preservice teachers' teaching efficacy and theories of effective mathematics teaching is a manifest indication of the effectiveness of the mathematics methods course, which provides student-centered, active, and reflective learning experiences. Change is an important issue in teacher professional growth. Positive change or enhancement can be seen as a result of training, adaptation, restructuring and learning (Clarke & Hollingsworth, 2002). The change in the preservice teachers' teaching efficacy and theories of effective mathematics teaching in a positive direction is desirable and meaningful results of a teacher preparation course.

4.1 Enhancing Teaching Efficacy in Managing Teaching Process, Adaption, and Interaction

The increase in the preservice teachers' teaching efficacy is an indicator of the effectiveness of the mathematics methods course, which provides sources of efficacy information: performance accomplishments, vicarious learning, emotional arousal, and verbal persuasion (Bandura, 1977; Enderlin-Lampe, 2002; Hampton & Mason, 2003). Repeated field-teaching as a form of mastery learning increases the chance of successful teaching. Team teaching and face-to-face and on-line dialogue provide the opportunity for vicarious learning. Field-teaching is a challenging task, in which preservice teachers have to face real 'students' and 'classroom settings,' which is likely to create more emotional arousal than micro-teaching, in which preservice teachers teach their classmates in the university. Verbal persuasion is provided by the course instructor, who emphasized a mastery approach and learning goals. In addition, multiple sources of emotional supports and encouragements were provided by peers, class teachers, and the course instructors through face-to-face and on-line dialogue.

Classrooms are complex environments full of interactions between knowledge and people and difficult to be successfully managed and controlled especially by a preservice teacher. Repeated field-teaching familiarizes preservice teachers with the environments and the teaching contents. Repeated field-teaching therefore can increase the opportunity to successfully adapt teaching methods to teaching contents, to fit to the needs of different students, to manage teaching processes, and to interact with students properly, as revealed by the significant increase in these aspects of teaching efficacy (Items 2, 3, 6, and 7 in Table 1). Perceived teaching efficacy in subject content knowledge and lesson designs are not

increased significantly (Items 1 and 5 in Table 1). The reason for this is likely to be that these two aspects are stable issues in teaching and can be prepared before teaching, which is likely to be not so sensitive to repeated field-teaching. Student engagement (Item 4 in Table 1) is an essential indicator of effective teaching and may be a later stage of teacher professional development. We can expect that preservice teachers can increase their efficacy belief in engaging students in their inservice stage if the sources of efficacy information are provided. The present tool for measuring teaching efficacy allows preservice teachers to provide their judgment of their capacities in a specific situation, i.e., their field-teaching. The context specificity of the measure for examining teaching efficacy is also likely to be an important factor in successfully capturing preservice teachers' changes in teaching efficacy because their own field-teaching can serve as an explicit stimulus (Bandura & Locke, 2003).

4.2 Enhancing Theories of Effective Teaching towards Advanced Approaches

The effectiveness of the mathematics methods course is also indicated by three patterns of changes in the preservice teachers' theories of effective mathematics teaching from more teacher-centered, theoretical, and procedural approaches towards more student-centered, practical, and thematic approaches. Student- or learner-centered teaching is a desirable teaching practice, which relates to positive learning outcomes and fits to educational ideals from the democratic, humanistic, developmental, constructivist, and psychological perspectives (Brodie, Lelliott, & Davis, 2002; Cornelius-White, 2007; Deboer, 2002). Inclusion of broader, external, and contextual factors into preservice teachers' pedagogical knowledge that is learned from teacher preparatory courses is a sign of 'multiple enactments of subjectivity' normally generated during field-teaching (to use Walshaw's (2004) term, p. 80). Sequential or procedural approaches to teaching are related to low teaching efficacy and low flexibility in the use of alternative teaching approaches, while thematic or meaning approaches are related to high teaching efficacy and flexibility (Agudelo-Valderrama, Clarke, & Bishop, 2007).

The three patterns of changes in the preservice teachers' theories also echo Clarke and Hollingsworth's (2002) interconnected model of teacher professional growth, in which four domains of change environments are identified: personal domain, external domain, domain of practice, and domain of consequences. A change from teacher- to student-centered approaches is a significant change in personal beliefs and pedagogical knowledge. A change from theoretical to practical approaches is a salient sign of access to external sources of information or stimuli. A change from procedural to thematic approaches indicates an exploring mind that can flexibly conduct professional experiments in teaching environments, in which teachers are also learners and researchers. The three patterns of changes also reveal a significant improvement from a 'technical model of teaching' (to use McDuffie's (2004) term, p. 33) that the preservice teachers might have learned as students to an advanced model of teaching.

4.3 Conclusion, Limitation of This Study and Future Research

A mathematics methods course for preservice teachers is designed to include repeated field-teaching with multiple supports. The major findings are as follows.

1. Preservice teachers' teaching efficacy increases after the repeated field-teaching in the aspects of pedagogy-content coordination, fluent teaching process, effective solution to student difficulties, and problem posing.
2. Preservice teachers' theories of effective mathematics teaching change from teacher-centered, theoretical, and procedural approaches to student-centered, practical, and thematic ones.

The preservice teachers worked together in groups in this study. Collective teaching efficacy in team teaching is an interesting variable to be included for exploration with personal teaching efficacy and personal or group theories of effective teaching (Bandura, 1999, 2000). Both personal teaching efficacy and collective teaching efficacy play an important role in how teachers actually manage their teaching and what students really experience in classrooms (Goddard, Hoy, & Hoy, 2000). Future research can also investigate the relationship between teaching efficacy, theories of effective teaching, and other related teacher beliefs and behaviors, e.g., goal setting, achievement calibration, efforts, self-regulation, teaching attitudes, epistemological beliefs, and actual teaching performance (Garavalia & Gredler, 2002; Philippou & Christou, 1998; Yilmaz-Tuzun & Topcu, 2008) especially in the situation of repeated field-teaching.

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