Preservice Biology Teachers' Learning to Teach Science through Science Methods Courses

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Abstract: This study tracked the changes of preservice biology teachers' pedagogical knowledge along with science teaching efficacy throughout sequentially developed science methods course I and II over two consecutive semesters. Two courses, science methods course I and II, aimed these preservice teachers to discuss the notion of science teaching with teaching and learning theories, to learn science instructional models, to design lessons utilizing science instructional models, and to eventually implement microteaching. The preservice teachers were mainly engaged in cooperative instructional planning activities through science methods course I, and engaged in cooperative microteaching activities through the science methods course II. This study revealed that preservice teachers successfully developed pedagogical knowledge and science teaching efficacy after two science methods courses. The science methods course I where cooperative instructional planning activities occurred helped the preservice teachers to improve pedagogical knowledge but not science teaching efficacy. Based on their pedagogical knowledge development, then, these preservice teachers increased science teaching efficacy belief after completion of the science methods course II.

Key words: preservice biology teacher, science methods course, pedagogical knowledge, science teaching efficacy

I. INTRODUCTION

Teacher preparation for preservice teachers may be the most influential stage to achieve effective science teaching practices (Hudson & Ginns, 2007). Preservice teacher education is a pivotal role for changing practice towards the inclusion of science education reform (Brunkhorst *et al.*, 1993). Anderson (1997) argues that science methods courses provided by teacher education programs play a role to connect theory and practice as well as bridge the gap between course work and student teaching. Through science methods courses, preservice teachers are capable to address the subject matter perspective and integrate the various teaching and learning perspectives (Anderson, 1997). Science methods courses further help preservice teachers move into self-directed professional development (Anderson, 1997).

Even though the significance of preservice science teacher education has increased, science methods courses vary and different educators provide different syllabus. Smith and Gess-Newsome (2004) explored a sample of 50 elementary science methods course syllabi and qualitatively analyzed using the six teaching standards. They found that universal inclusion related to the standards did not exist. Many studies have further developed science methods courses and examined their effectiveness (e.g., Boone & Anderson, 1994; Ramaswany *et al.*, 2001). Kim (2012) explored changes of preservice teachers' pedagogical knowledge and science teaching efficacy after the science methods course that provided students with opportunities of instructional planning based on teaching and learning theories. As shown in Figure 1, the current study added the teaching application course (named as science method course II) following the theory course (named as science methods course I) to Kim's (2012) study and examined preservice teachers' changes of both pedagogical knowledge and teaching efficacy.

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Pedagogical knowledge and science teaching self-efficacy are predictors of future science teaching success of preservice teachers as well as fundamental indicators of how preservice science teachers develop reform-based science teaching agendas (Kim, 2012).

This study aimed to track changes of preservice science teachers' pedagogical knowledge and self-efficacy after sequentially developed science methods courses I and II over two consecutive semesters (Fig 1). Specifically, this study attempted to answer the following research questions: (1) How did preservice science teachers' pedagogical knowledge change over the duration of science methods course I and II? (2) How did preservice science teachers' science teaching efficacy belief change throughout the science methods course I and II?

Ⅱ. THEORETICAL FRAMEWORK

Pedagogical knowledge

Teaching is a complex activity that requires many knowledge domains, such as subject matter knowledge, classroom management, students' preconceptions on specific content, teaching strategies, and so on. Pedagogical knowledge is defined by the knowledge of students, curriculum, planning instruction, and evaluation (Jones & Vesilind, 1996). Morine-Dershimer and Kent (1999) identified pedagogical knowledge in relation to classroom organization and management, instructional models and strategies, and classroom communication and discourse. Carlsen (1999) identified general pedagogical knowledge as learners and learning, classroom management, general curriculum and instruction. Sulman (1986) proposed pedagogical content knowledge (PCK) defined as "the particular form of content knowledge that embodies the aspects of content most germane to its teachability" (p.9) by placing pedagogical knowledge into a context.

Many studies have made an effort to develop pedagogical knowledge in various ways. Some studies focused on the development of pedagogical content knowledge for a specific content area (e.g., van Driel *et al*, 2002). Hudson and Ginns (2007) examined the influence of a science pedagogy course (one semester duration) which includes lecture of constructivism, the social nature of learning, conceptual change, instructional designs and the workshops of the implementation of elementary science lessons. The study result indicated that the course was effective in developing presevice elementary teachers' pedagogical knowledge.

Even though the role of preservice teacher education program has emphasized in science

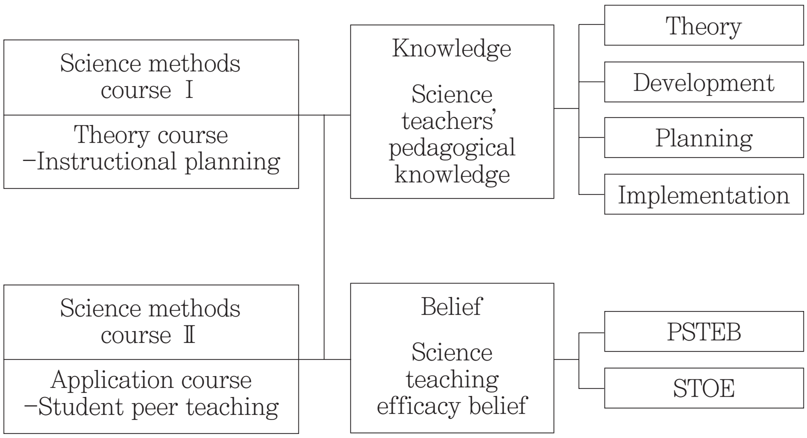

Fig. 1 *The schematic of current study*

education, the literature review revealed that few studies have examined secondary preservice science teachers' growth of PK along with science teaching efficacy during their teacher education programs.

Science teaching efficacy

Teacher efficacy is an important factor in educational research (Lakshmanan *et al.*, 2011). Bandura (1997) defined perceived self-efficacy as "belief in one's capabilities to organize and execute the courses of action required to produce given attainments"(p. 3). Similarly, teachers' self-efficacy refers to the beliefs of teachers that he or she has ability to bring about positive student change (Gibson & Dembo, 1984). Self-efficacy is comprised of two distinct constructs, efficacy expectations and outcome expectations (Bandura, 1977). In science teaching, efficacy expectation is defined as a teacher's belief regarding his or her own ability to teach science effectively, and outcome expectancy as a teacher's belief that student learning can be influenced by effective teaching (Enochos & Riggs, 1990; Ramey-Gassert & Enochs, 1990, cited from Cannon & Scharmann, 1996).

Bandura (1997) suggested four strategies for developing self-efficacy: mastery experience, vicarious experience, social and verbal persuasion, and physical and emotional states. The first strategy, mastery experience, describes that an increase in self-efficacy occurs when individuals master or achieve success at a certain task (Bandura, 1997). Mastery experience is the most powerful sources of information in the development of self-efficacy (Bandura, 1994). The second source, vicarious experience, is characterized that seeing people similar to oneself success by sustained effort increases observer's self-efficacy. Bandura (1994) argues that perceived similarity to the models strongly increases the impact of modeling on perceived self-efficacy. The third source, social persuasion is described as positive reinforcement or expression of motivation and support increase of one's self-efficacy. The final source, somatic and emotional states mention that positive mood enhances perceived self-efficacy.

Science teaching efficacy beliefs are a consistent predictor of beginning teachers' success or failure (Park, 2006; Scharmann & Hampton, 1995). Likewise, Cantrell *et al.* (2003) maintain that a specific measure of science teaching efficacy beliefs may play a role as a predictor of future science teaching success of preservice teachers.

Ⅲ. METHODOLOGY

1. Participants and Description of Courses

A total of 42 preservice biology teachers (9 men, 33 women) with a mean age of 23 (ranging from 21-28) who were enrolled in a college of education participated in this study. They were all in a program for secondary biology science teachers and were in their third year of college.

All of the preservice teachers participated in this study were enrolled in the science methods course I and II over two consecutive semesters. Students were enrolled in the science methods course I (theory course, three credit hours) during the autumn semester, and the science methods course II (application course, three credit hours) during the next calendar year of spring semester (Fig 2). The preservice teachers were mainly engaged in cooperative instructional design through science methods course I and in cooperative microteaching experiences through science methods course II. This study utilized cooperation as a pedagogical method since several studies have reported that science methods courses utilizing cooperative learning strategies that incorporate investigating and sharing ideas are beneficial for fostering effective science teaching (e.g., Cannon & Scharmann, 1996; Watters & Ginns, 2000).

As shown in Figure 2, the science methods course I is the theory course that aims for students to learn about theories of learning and science instructional design models, and to finally design lessons utilizing appropriate instructional models during one semester. The science methods course II is the application course that requires students to select a unit, design a lesson plan, do microteaching and reflect on their teaching with peers (Fig 2). The preservice teachers in this class participated as students or as teachers. That is, as teachers, two students grouped together and selected a unit for microteaching. They were asked to survey about students' misconceptions about the unit, design an inquiry-based lesson according to students' misconception on the unit, and had an experience of microteaching to their peers. As students, the preservice teachers usually work as a group to perform inquiry activities. After microteaching, the class discussed about content-specific concepts, teaching strategies, and appropriateness of activities adopted for a specific topic to improve their teaching in future. Further, microteachings were videotaped so that these students see their own teaching again and reflect on their teaching. Overall, students mainly had opportunities of cooperative instructional design through science methods course I and cooperative microteaching experiences through science methods course II. Both courses utilized cooperation and reflection as a main teaching strategy to facilitate students' learning to teach science (Fig 2).

2. Data Collection and Data Analyses

Two instruments, pedagogical knowledge and science teaching efficacy belief instrument, were distributed before the science methods course I (pretest), right after the science methods course I (posttest I), as well as right after the science methods course II (posttest II).

Pedagogical Knowledge Instrument

This instrument developed by Hudson and Ginns (2007) was used to examine preservice teachers' pedagogical knowledge. Four constructs were measured: (1) understanding the

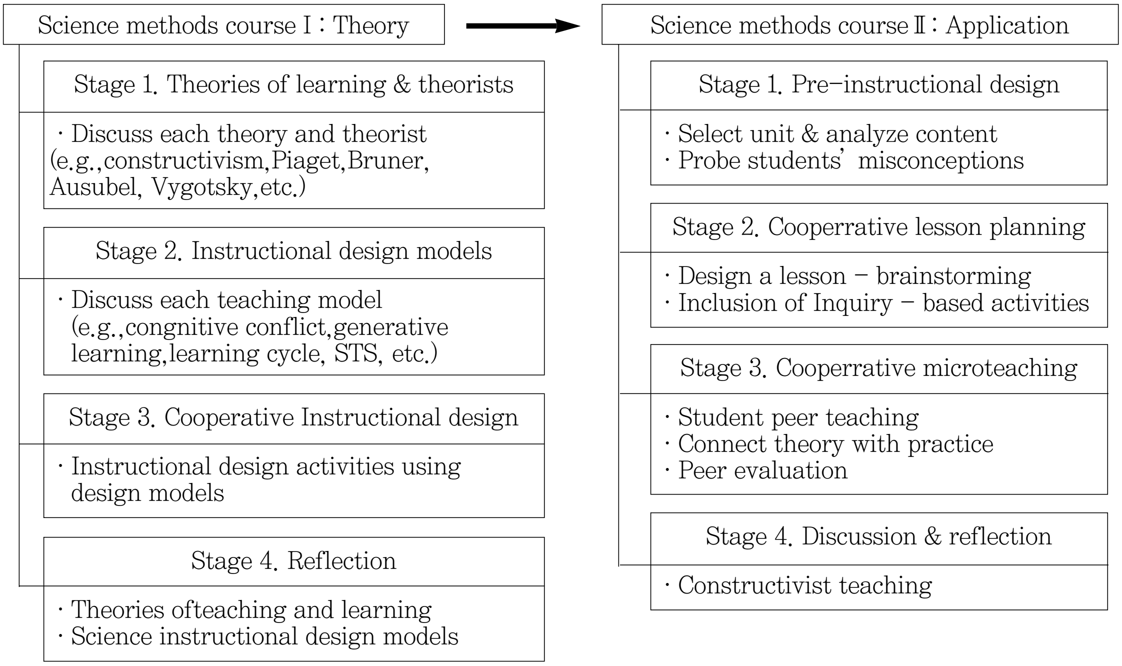

Fig. 2 *Main themes of science methods course I & II*

theory for developing a science curriculum (construct: Theory); (2) understanding the development of students' concepts, abilities, skills, and attitudes (construct: Students' Development); (3) understanding effective planning for science teaching and learning (construct: Planning); (4) implementing effective science teaching practices (construct: Implementation). The Cronbach alpha values of four constructs, theory, students' development, planning and implementation, are respectively 0.76, 0.64, 0.64, and 0.83. The instrument is a five choice Likert-type scale with strongly disagree, disagree, uncertain, agree, and strongly agree as possible item responses. The descriptive statistics and the Repeated measures of ANOVA were implemented on each construct (Theory, Development, Planning, Implementation) to examine if there are changes in students' scores of pedagogical knowledge after science methods course I and II.

Science Teaching Efficacy Belief Instrument (STEBI-B)

The Science Teaching Efficacy Belief Instrument developed by Enochs and Riggs (1990) was utilized to measure preservice teacher confidence in teaching science. The STEBI -B consists of two subscales, the 13-item Personal Science Teaching Efficacy Belief (PSTEB) Scale, which assesses the belief that one's own teaching ability can be developed, and the 10-item Science Teaching Outcome Expectancy (STOE) Scale, which assesses the belief that student learning can be influenced by effective teaching (Enochs & Riggs, 1990). In this study, the Cronbach alpha for Personal Science Teaching Efficacy Belief was .74 and Science Teaching Outcome Expectancy was .80. The descriptive statistics as well as the repeated measures of ANOVA were performed to investigate whether students change their scores of science teaching efficacy belief after science methods course I and II.

Ⅳ. RESULTS AND DISCUSSION

1. Pedagogical Knowledge

The pedagogical knowledge, consisting of four constructs, theory, development, planning, implementation, was measured before (pretest) and after the intervention (posttest I and posttest II). Table 1 and Figure 3 show the changes of scores of pedagogical knowledge after the science methods course I and II.

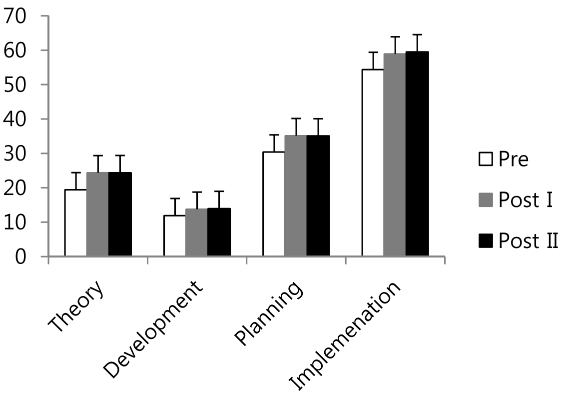

Fig. 3 *The bar graph of the mean scores of the pretest, posttest I, and posttest II of pedagogical knowledge*

Table 1
Descriptive statistics of pedagogical knowledge

	Theory(n=42)		Development(n=42)		Planning(n=42)		Implementation(n=42)	
	M	SD	M	SD	M	SD	M	SD
Pre	19.40	3.575	11.90	2.046	30.38	4.231	54.38	5.885
Post I	24.36	2.945	13.76	1.495	35.14	2.514	58.90	4.957
Post II	24.38	2.556	13.95	1.431	35.07	3.056	59.52	3.846

Theory for Developing Science Curriculum

The construct 'theory' includes seven indicators (e.g., articulate constructivist principles for teaching science; compare existing approaches for teaching science) that measure students' understanding of the theoretical underpinnings for developing science curriculum. The Repeated measures of ANOVA indicates that there is a significant effect of theory over time (F[1, 41]=4300.917, $p < .01$)(Table 2). The pairwise comparison results (Table 3) indicate that the preservice teachers significantly increased the mean scores of 'theory' construct in the posttest I compared to the pretest ($p < .01$), while there is no change of the mean scores of the construct 'theory' in the posttest II compared to the posttest I ($p > .05$) .

The t-tests between the pretest and the posttest I, as well as between the posttest I and the posttest II were performed in order to examine which indicators' scores were improved after the science methods course I and II (Table 4). In the posttest I compared to the pretest, six indicators' scores among seven indicators significantly increased ($p < .01$) except the indicator 'talking about science'. Instructional planning activities required students to integrate the theories of science teaching and learning (Kemp *et al.*, 1994), considering each indicator of theory, such as key components of science syllabus, a rationale for an effective science program, approaches for teaching science, and so on.

Notably, in the posttest II compared to the posttest I, students significantly increased their scores of the indicator 'constructivist' as well as 'talking about science' even though the total posttest II scores did not significantly increase. Especially, the indicator 'constructivist' scores significantly increased twice in both the posttest and the delayed posttest (Table 4). This result implicated that both science methods course I and II helped students gain insights of constructivism. The two courses provided in this study articulated the notion of constructivism through opportunities of collaboration and reflection. The instructor asked each group to brainstorm and reflect the aspects of 'constructivist teaching approaches' in their lesson plans as well as in their microteaching. After each microteaching, especially, the class discussion focused on better instructional strategies to become constructivist teaching. Therefore, facilitating discussions and reflection on their lesson plans and microteaching helped these prospective science teachers understand the complexity of science teaching and gain insights of reform-based science teaching (Abell & Bryan, 1997). Nilsson (2008) likewise emphasized the importance of team teaching for aiding preservice teachers to realize the complication of the classroom and careful reflection on their teaching.

Students' Development regarding to Concepts, Abilities, and Attitudes

The construct 'development' measures understanding of concepts, abilities, skills, and attitudes, and consists of four indicators (e.g., discuss the development of students scientific reasoning abilities; discuss the development of students attitudes for learning secondary

Table 2

The Repeated-measures of ANOVA result of Theory

Source	Type III sum of squares	df	Mean square	F	Sig.
Intercept	65008.286	1	65008.286	4300.917	.000**
Error	619.714	41	15.115		

**$p < .01$

Table 3
The Pairwise comparison result of Theory

(I)	(J)	Mean Difference (I−J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
					Lower Bound	Upper Bound
Pre	Post I	− 4.952*	.598	.000	−6.445	−3.460
	Post II	−4.976*	.590	.000	−6.448	−3.504
Post I	Pre	4.952*	.598	.000	3.460	6.445
	Post II	−.024	.463	1.000	−1.179	1.132
Post II	Pre	4.976*	.590	.000	3.504	6.448
	Post I	.024	.463	1.000	−1.132	1.179

Based on estimated marginal means
**The mean difference is significant at the .05 level*
a Adjustment for multiple comparisons: Bonferroni

Table 4
The t−test results on the construct Theory

Indicator	Pretest−Posttest I					Posttest I−Posttest II				
	M	*SD*	t	*df*	*p*	*M*	*SD*	t	*df*	*p*
Syllabus	−.857	.872	−6.374	41	.000**	.116	.731	1.044	42	.303
Rationale	−.810	1.042	−5.037	41	.000**	.256	1.049	1.600	42	.117
Theory	−.905	.759	−7.725	41	.000**	.140	.675	1.355	42	.183
Constructivist	−.619	.962	−4.172	41	.000**	−.419	.698	−3.932	42	.000**
Teaching Approaches	−.786	.898	−5.670	41	.000**	−.070	.799	−.573	42	.570
Viewpoints	−.810	.943	−5.562	41	.000**	.093	.781	.781	42	.439
Talking About Science	−.167	.696	−1.553	41	.128	−.209	.638	−2.150	42	.037*

$^{*}p < .05$; $^{**}p < .01$

science; demonstrate an understanding of the development of students manipulative skills for investigating science; discuss the development of students science concepts). The mean scores of the construct 'development' significantly changed over time ($F[1,41]= 5280.220$, $p<.01$) (Table 5). According to the Pairwise comparison results (Table 6), the preservice teachers significantly increased their scores of 'development' in the posttest I compared to the pretest after science methods course I. However, the mean scores of posttest I and the mean scores of posttest II were not significantly different, implicating that cooperative teaching experiences provided by the science methods course II did not help these teachers increase the mean scores of the construct 'development'. According to the Table 7, the mean scores of all the indicators of 'development' (e.g., scientific reasoning, attitude, manipulative skills, science concepts) significantly increased after the science methods course I, while no significant increase after the science methods course II. The 'scientific reasoning' indicator represented the most score increase and 'manipulative skills' indicator next score increase in the posttest II. Supovits and Turner (2000) pointed out the importance of inquiry, practice questioning, and experimentation. Within the science methods course I, inquiry activities adopted in each lesson plan apparently helped these preservice teachers develop understanding of scientific reasoning and manipulative skills. This study, on the other hand, revealed that microteaching experiences to peers through the science methods course II were not sufficient for these prospective teachers to further enhance their understanding of the development of students' scientific reasoning abilities, manipulative skills and attitudes. This study suggests that field experiences within real classrooms need to make inclusion of reflection on students' reasoning abilities, attitude toward science, and development of manipulative skills.

Effective Planning for Science Teaching and Learning

The 'planning' construct measures preservice teachers' understanding of effective planning for science teaching and learning, and consists of ten indicators (e.g., devise clear lesson structures; develop a scope and sequence for teaching secondary science; articulate the components of an effective secondary science program). The Repeated measures of ANOVA indicated that there was a statistically significant change of the mean scores of the construct 'planning' among the pretest, posttest I, and posttest II ($F[1,41]= 9170.799$, $p<.01$) (Table 8). The Pairwise comparison results (Table 9) represented that these preservice teachers

Table 5
The Repeated-measures of ANOVA result of Development

Source	Type III sum of squares	df	Mean square	*F*	Sig.
Intercept	21975.365	1	21975.365	5280.220	.000**
Error	170.635	41	4.162		

**$p < .01$

Table 6
The Pairwise comparison result of Development

(I)	(J)	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
					Lower Bound	Upper Bound
Pre	Post I	-1.857*	.357	.000	-2.748	-.967
	Post II	-2.048*	.310	.000	-2.822	-1.273
Post I	Pre	1.857*	.357	.000	.967	2.748
	Post II	-.190	.290	1.000	-.914	.533
Post II	Pre	2.048*	.310	.000	1.273	2.822
	Post I	.190	.290	1.000	-.533	.914

Based on estimated marginal means
*The mean difference is significant at the .05 level
a Adjustment for multiple comparisons: Bonferroni

Table 7
The t-test results on the construct Development

Indicator	Pretest-Posttest I					Posttest I-Posttest II				
	M	*SD*	t	*df*	*p*	*M*	*SD*	t	*df*	*p*
Scientific Reasoning	-.619	1.011	-3.968	41	.000**	-.140	.774	-1.182	42	.244
Attitude	-.357	1.008	-2.297	41	.027*	-.140	.710	-1.289	42	.204
Manipulative Skills	-.476	.890	-3.467	41	.001**	.000	.787	.000	42	1.000
Science Concepts	-.405	.885	-2.964	41	.005**	.070	.704	.650	42	.519

$^{*}p < .05$; $^{**}p < .01$

significantly increased their scores of 'planning' construct after the science methods course I where students mainly experienced cooperative instructional design activities, while no statistical difference was found between the posttest I and posttest II, indicating that science methods course II did not dedicate to develop students' understanding of 'planning'. In the posttest I, all the indicators' scores except the indicator 'integrate' significantly increased compared to the prettest. In the posttest II, on the other hand, the score of the indicator of 'integrate' only significantly increased compared to the posttest I (Table 10).

Bellon *et al.* (1992) argued that planning is a cyclic process of preactive, active, and postactive. In this study, students had an opportunity of experiencing preactive and active stage. The science methods course I only provided the preservice teachers with the preactive stage of planning lessons along with science instructional models, reflecting the theories of science teaching and learning. In addition, the science methods course II provided students with the active stage of implementing their lesson plan to peers. This study suggests that the inclusion of postactive stage that resolves problems of instructional planning and elaborates their plan help students further develop understanding of each indicator of planning (e.g., 'devise clear lesson structures for teaching primary science', 'develop a scope and sequence for teaching science', and 'select appropriate activities and resources for teaching science').

Implementing Science Teaching Practices

The construct 'implementation' examines preservice teachers' understanding of implementing effective science teaching practices. In this construct, 16 indicators are included (e.g., provide a problem-based learning environment for teaching secondary science; implement appropriate secondary science teaching strategies). According to the Repeated measures of ANOVA results, a statistically significant difference was found among the pretest, posttest I, and posttest II ($F[1,41]= 10074.356$, $p<.01$)

Table 8
The Repeated-measures of ANOVA result of Planning

Source	Type III sum of squares	df	Mean square	*F*	Sig.
Intercept	141671.627	1	141671.627	9170.799	.000**
Error	633.373	41	15.448		

$^{**}p < .01$

Table 9
The Pairwise comparison results of Planning

(I)	(J)	Mean Difference (I−J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a] Lower Bound	Upper Bound
Pre	Post I	−4.762*	.696	.000	−6.167	−3.357
	Post II	−4.690*	.758	.000	−6.221	−3.160
Post I	Pre	4.762*	.696	.000	3.357	6.167
	Post II	.071	.485	.884	−.908	1.051
Post II	Pre	4.690*	.758	.000	3.160	6.221
	Post I	−.071	.485	.884	−1.051	.908

Based on estimated marginal means
*The mean difference is significant at the .05 level
a Adjustment for multiple comparisons: Bonferroni

Table 10
The t−test results on the construct Planning

Indicator	Pretest−Posttest I					Posttest I−Posttest II				
	M	*SD*	t	*df*	*p*	*M*	*SD*	t	*df*	*p*
Lesson Plans	−.786	1.048	−4.857	41	.000**	.070	.704	.650	42	.519
Scope and Sequence	−.643	.850	−4.900	41	.000**	.116	.793	.961	42	.342
Program	−.738	.912	−5.244	41	.000**	.116	.731	1.044	42	.303
Outcomes	−.524	1.215	−2.795	41	.008**	−.070	.828	−.553	42	.583
Affective Domain	−.524	.833	−4.073	41	.000**	−.070	.828	−.553	42	.583
Integrate	−.143	.843	−1.098	41	.279	−.256	.693	−2.420	42	.020*
Independent Collaborate	−.333	.874	−2.471	41	.018*	.140	.743	1.232	42	.225
Appropriate Activity	−.262	.665	−2.553	41	.014*	.070	.552	.829	42	.412
Inclusivity	−.357	1.078	−2.147	41	.038*	−.093	.895	−.682	42	.499
Concept Map	−.548	.705	−5.031	41	.000**	.209	.888	1.546	42	.130

$^*p < .05$; $^{**}p < .01$

(Table 11). The pairwise comparison results (Table 12) revealed that the pretest scores and the posttest I scores were significantly different each other ($p<.01$), representing that students improved their scores of 'implementation' after science methods course I. However, no score difference between the posttest I and the posttest II was found ($p>.05$), implicating that these preservice teachers did not improve their understanding of implementation after science methods course II.

The t−test result (Table 13) indicated that in the posttest I, students significantly increased their scores on the nine indicators among sixteen compared to the pretest. On the other hand, the posttest II scores did not significantly change in the all indicators of 'implementation' ($p>.05$). Notably, the scores of 'appropriate secondary science teaching strategies' indicator most increased in the posttest I compared to the pretest. Even though students experienced cooperative microteaching in the science methods course II, no score improvement on the construct 'implementation' in the posttest II compared to the posttest I ($p>.05$). This result implicated that microteaching experience was not sufficient to develop the notions of 'implementation'. The indicators, such as classroom management, learning environment, and questioning skills, should deal with real class settings. Student-teaching experiences targeting these indicators at school context will help these preservice teachers further develop the notion of 'implementation' (Weld & French, 2001).

2. Science Teaching Efficacy Belief

Along with pedagogical knowledge, perservice teachers' science teaching efficacy belief, consisting of PSTEB and STOE, was examined after the science methods course I and II. The preservice teachers' score changes of science teaching efficacy belief were demonstrated in the Table 14 and Figure 4.

Personal Science Teaching Efficacy Belief (PSTEB) Scale

The Repeated measures of ANOVA results indicated that preservice teachers significantly changed their PSTEB scores over time ($F[1,41]=6735.503$, $p<.01$) (Table 15). The Pairwise comparison result indicates that there was no statistically significant change between the pre-PSTEB and post I-PSTEB scores ($p>.05$), while

Table 11

The Repeated-measures of ANOVA result of Implementation

Source	Type III sum of squares	df	Mean square	F	Sig.
Intercept	418083.841	1	418083.841	10074.356	.000**
Error	1701.492	41	41.500		

**$p < .01$

Table 12

The Pairwise comparison results of Implementation

(I)	(J)	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
					Lower Bound	Upper Bound
Pre	Post I	-4.762*	.696	.000	-6.167	-3.357
	Post II	-4.690*	.758	.000	-6.221	-3.160
Post I	Pre	4.762*	.696	.000	3.357	6.167
	Post II	.071	.485	.884	-.908	1.051
Post II	Pre	4.690*	.758	.000	3.160	6.221
	Post I	-.071	.485	.884	-1.051	.908

Based on estimated marginal means
*The mean difference is significant at the .05 level
a Adjustment for multiple comparisons: Bonferroni

Table 13
The t-test results on the construct Implementation

Indicator	Pretest-Posttest I					Posttest I-Posttest II				
	M	*SD*	t	*df*	*p*	*M*	*SD*	t	*df*	*p*
Problem-Based Learning	-.524	1.087	-3.122	41	.003**	-.093	.718	-.850	42	.400
Strategies	-.786	.842	-6.047	41	.000**	-.093	.526	-1.159	42	.253
Classroom Management	-.238	.932	-1.655	41	.105	-.163	.814	-1.311	42	.197
Learning Environment	-.357	.821	-2.819	41	.007**	-.023	.597	-.255	42	.800
Ethical Issues	-.262	.701	-2.423	41	.020*	.047	.486	.628	42	.533
Unit of work	-.333	.846	-2.554	41	.014*	.070	.737	.621	42	.538
Assessments	-.286	.742	-2.496	41	.017*	.093	.610	1.000	42	.323
Critical Reflection	-.143	.566	-1.635	41	.110	-.116	.544	-1.402	42	.168
Questioning Skills	-.405	.798	-3.287	41	.002**	-.023	.707	-.216	42	.830
Evaluate	-.405	.885	-2.964	41	.005**	-.070	.669	-.684	42	.498
Teach in Other Cities	-.095	.656	-.942	41	.352	.000	.655	.000	42	1.000
Hands-on Lessons	-.214	.682	-2.036	41	.048*	-.047	.785	-.388	42	.700
Content Knowledge	-.143	.843	-1.098	41	.279	-.163	.871	-1.226	42	.227
Teaching Confidently	-.167	.660	-1.638	41	.109	-.070	.704	-.650	42	.519
Positive Attitudes	-.119	.670	-1.152	41	.256	-.023	.462	-.330	42	.743
Teach Other Countries	-.048	1.011	-.305	41	.762	-.070	1.142	-.401	42	.691

$^*p < .05$; $^{**}p < .01$

Table 14
The descriptive statistics of PSTEB and STOE

	PSTEB (n=42)		STOE (n=42)	
	M	SD	M	SD
Pre	44.93	4.338	34.86	3.475
Post I	46.12	4.014	34.86	3.440
Post II	47.73	3.225	37.33	4.040

the statistically significant change was found between the post I-PSTEB and post II-PSTEB scores ($p < .05$), representing that students increased their PSTEB scores after science methods course II (Table 16).

Science Teaching Outcome Expectancy (STOE) Scale

According to the Table 17, the Repeated measures of ANOVA results represent that there is a statistically significant change of STOE scores over time ($F[1,42] = 4208.402$, $p < .01$). The preservice teachers' post II-STOE scores significantly increased after the science method course II with cooperative microteaching experiences ($p < .01$) (Table 18). However, the

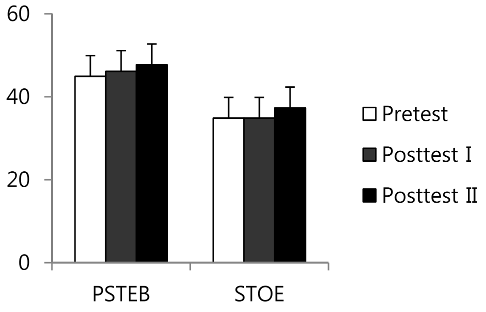

Fig. 4 *The bar graph of the mean scores of the pretest, posttest I, and the posttest II of PSTEB and STOE*

science methods course I did not help these preserivce teachers increase the mean scores of STOE in the posttest I compared to the pretest ($p > .05$).

Overall, science teaching efficacy belief scores including both PSTEB and STOE measured by STEBI-B were significantly increased after science method course II (mainly cooperative microteaching experiences), while no score differences were found before and after the science methods course I (where mainly occurs cooperative inquiry-based lesson plan activities along with science instructional models). These findings are consistent with studies that mastery experiences have the greatest impact on efficacy belief (Brand & Wilkins, 2007; Tschannen-Moran *et al.*, 1998). In the science methods course II different from the science methods course I, students became a biology teacher and taught the class a specific biology topic assuming that their peers were students. Bandura (1997) emphasized the importance of mastery experience in order to enhance science teaching efficacy. All of preservice teachers experienced the whole process of teaching, and

Table 15
The Repeated-measures of ANOVA result of PSTEB

Source	Type III sum of squares	df	Mean square	F	Sig.
Intercept	265421.341	1	265421.341	6735.503	.000**
Error	1615.659	41	39.406		

**$p < .01$

Table 16
The Pairwise comparison results of PSTEB

(I)	(J)	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
					Lower Bound	Upper Bound
Pre	Post I	-4.762*	.696	.000	-6.167	-3.357
	Post II	-4.690*	.758	.000	-6.221	-3.160
Post I	Pre	4.762*	.696	.000	3.357	6.167
	Post II	.071	.485	.884	-.908	1.051
Post II	Pre	4.690*	.758	.000	3.160	6.221
	Post I	-.071	.485	.884	-1.051	.908

on estimated marginal means
*The mean difference is significant at the .05 level
a Adjustment for multiple comparisons: Bonferroni

Table 17
The Repeated-measures of ANOVA result of STOE

Source	Type III sum of squares	df	Mean square	*F*	Sig.
Intercept	161402.860	1	161402.860	4208.402	.000**
Error	1610.806	42	38.353		

**$p < .01$

Table 18
The Pairwise comparison results of STOE

(I)	(J)	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
					Lower Bound	Upper Bound
Pre	Post I	-.767	.918	.408	-2.620	1.085
	Post II	-3.209*	.917	.001	-5.060	-1.358
Post I	Pre	.767	.918	.408	-1.085	2.620
	Post II	-2.442*	.613	.000	-3.679	-1.205
Post II	Pre	3.209*	.917	.001	1.358	5.060
	Post I	2.442*	.613	.000	1.205	3.679

on estimated marginal means
*The mean difference is significant at the .05 level
a Adjustment for multiple comparisons: Bonferroni

received reinforcement from the instructor and their peers. Therefore, these preservice teachers could reach some levels of mastery that result in significant increase of science teaching efficacy. Along with mastery experience, students observed other groups' microteaching and thereby could be capable of self-percept that they master comparable activities, which were placed into vicarious experience (Bandura, 1997). Especially, teaching experiences followed by reflection facilitate teachers' revisiting and reframing their teaching practices (Byran & Abell, 1999) and thus increase these preservice teachers' science teaching self-efficacy.

V. CONCLUSION AND IMPLICATION

This study described the changes of preservice biology teachers' pedagogical knowledge and science teaching efficacy belief after two consecutive science methods courses. The science methods courses I is the theory course that incorporates learning educational theories and planning lessons along with science instructional models. The follow-up science methods course II is the application course where student peer teaching occurred. Throughout the two courses, students learned how to plan and teach secondary science. This study revealed that the preservice teachers who completed two consecutive science methods courses significantly improved pedagogical knowledge as well as science teaching efficacy.

Both science methods courses facilitated students' active participation of cooperation and reflection on the processes of planning lessons and microteaching. Science methods courses utilizing cooperative learning strategies that incorporate investigating and sharing ideas are beneficial for enhancing science teaching efficacy belief and fostering effective science teaching. This study, likewise, implicated that cooperative lesson planning and cooperative teaching activities helped preservice teachers share their thought, extensively engaged in reflection in how to plan and teach science, and thereby increased pedagogical knowledge and self efficacy.

It is notable that the theory course dedicated to only improve pedagogical knowledge not science teaching efficacy belief, whereas the application course devoted to increase science teaching efficacy belief, not pedagogical knowledge. This study suggests that inclusion of connecting microteaching experiences with appropriate elements of pedagogical knowledge helps further growth of pedagogical knowledge as well as science teaching efficacy belief. Gradual increase of both pedagogical knowledge and science teaching efficacy belief during the preservice teacher education dedicates to success of science education reform movement. Finally, the analyses and description of the ways about how these students' pedagogical knowledge and science teaching efficacy were evolved will provide tips for further program development such as a follow-up course of field experience to science teacher educators.

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