

Nurturing reflective teaching during critical-thinking instruction in a computer simulation program

Yu-Chu Yeh*

Institute of Teacher Education, National Chengchi University, 64, Chih-nan Rd., Sec. 2,
Wenshan, Taipei 116, Taiwan

Abstract

Nurturing reflective teaching and improving critical-thinking instruction are two important goals in teacher education, but these are only achievable when teachers-in-training are provided with opportunities for building professional knowledge and for exhibiting reflective teaching practices. A computer simulation program (CS-TGCTS) was therefore developed here, and its effectiveness is explained in this study. From 149 preservice teachers participating in this study, a pretest–posttest control group design was defined by four student groups and two treatments. The central hypothesis was that increasing participants' self-awareness of teacher behaviors and enhancing mindful learning in professional knowledge would provoke reflective teaching and further bring about improvements in teacher behaviors. The findings support the hypothesis and suggest that the CS-TGCTS simulation is an effective vehicle for improving preservice teachers' reflective teaching in critical-thinking instruction.

Keywords: *Architectures for educational technology systems; Interactive learning environment; Simulations and Teaching/learning strategies.*

1. Introduction

Many recent studies have addressed the importance of nurturing reflective teaching in teacher education (Collier, 1999, Kahne and Westheimer, 2000, Larson, 2000, O'Neill, 2000, Rodriguez and Sjostrom, 1998, Titone et al., 1998, Waks, 1999). Reflective teaching refers to a purposeful and systematic inquiry into an instructor's own personal theories about teaching and learning as well as the practices dictated by those theories. It follows then that reflective teachers

are competent in thinking about their own teaching, reframing problems, and in exercising flexibility when revising personal theories; accordingly, they are able to improve their teaching skills (Abell, Bryan, & Anderson, 1998). Such competencies are crucial especially for novice teachers wanting to become experts in their field.

Practice sessions in reflective teaching must be centered upon certain content areas. Well-chosen teaching content not only enables teachers to improve their abilities and increase their motivation to teach reflectively but also greatly increases their competence to teach that content successfully and effectively. One important content area that has long been emphasized is critical thinking. The importance of critical thinking lies in its functions of being an effective learning strategy (Browne & Meuti, 1999; Gadzella & Masten, 1998; Halpern, 1998; Hittner, 1999; Klein, Olson, & Stanovich, 1997; Lawson, 1999; McCarthy-Tucker, 2000), a key to emotional intelligence (Elder, 1997), and a requirement for leaders in business (Harris & Eleser, 1997). It would, therefore, be invaluable to design a course which infuses the learning of reflective teaching into the teaching of critical thinking.

According to Abell et al. (1998), reflective teaching focuses on teachers' capacities to reconstruct their personal theories with respect to teaching and learning and, further, it maximizes their creative ability to improve their own teaching practices. Thus, if a teacher training program is to nurture reflective teachers, it must provide them with realistic opportunities to practice their newly-learned skills in typical classroom settings. Incorporating such practices in a teacher program, however, is often difficult due to time, place, and other constraints. Fortunately, computer simulations provide an alternative setting for teachers-in-training to become knowledgeable and skillful instructors (e.g. Haneghan & Stofflett, 1995; Kenny, Covert, Schilz, Vignola, & Andrews, 1995; Strang & Yeh, 1995; Yeh, 1997).

In light of the importance of cultivating reflective teachers, the support for the teaching of critical thinking as well as the value of computer simulations, I developed a computer simulation program: *Computer Simulation for Teaching General Critical-thinking Skills* (CS-TGCTS). The CS-TGCTS program is aimed at cultivating reflective teachers during the simulated teaching of critical-thinking skills. To achieve this goal, several interventions were incorporated into the program and their effectiveness was examined in the current study.

2. Theoretical bases for nurturing reflective teaching in critical-thinking instruction

2.1. Indices for reflective teaching in critical-thinking instruction

Definitions of reflective teaching (Abell et al., 1998; Longhrm, 2002) have indicated that the performance of professional knowledge and teacher behaviors are two indices for understanding a preservice teacher's level of reflectivity in his/her teaching practices. As the CS-TGCTS program was designed to infuse the learning of reflective teaching into the teaching of critical thinking, it is obviously essential that the important components of the two indices concerning teaching critical thinking be identified and that the key elements be incorporated into the program. Drawing upon earlier research findings (e.g. Facione, Sanchez, Facione, & Gainen, 1995; Garcia & Pintrich, 1992; Halpern, 1998; Haneghan & Stofflett, 1995; Harris & Eleser, 1997; Larson, 2000; McBride & Knight, 1993; Michelli, Pines, & Oxman-Michelli, 1990), I have

identified two types of professional knowledge and three categories of teacher behaviors concerning the effective teaching of critical thinking.

The two types of professional knowledge are content knowledge and pedagogical content knowledge. In teaching critical thinking, “content knowledge” involves a teacher’s understanding of the definition and construct of critical thinking, the prerequisites of a good critical-thinker, and the factors that influence students’ learning of critical thinking skills. On the other hand, “pedagogical content knowledge” takes into account a teacher’s knowledge as to how to tailor-design a curriculum to teach students critical thinking, how to select the most effective pedagogies for imparting critical-thinking skills to the target group, how to best employ effective teacher behaviors during their teaching, and how to reliably assess students’ critical-thinking ability (Facione et al., 1995; Halpern, 1998; Harris & Eleser, 1997; McBride & Knight, 1993; Michelli et al., 1990).

As for the three categories of effective teacher behaviors for teaching critical thinking, the first involves increasing students’ prior knowledge, and this includes providing them with advance organizers and reviewing material. The second category of teacher behaviors that focuses on enhancing students’ critical-thinking dispositions comprises six components: keeping students focused on undertaking tasks or discussions; giving them time for thinking; allowing a variety of student answers; giving cues when students can not answer correctly; giving positive feedback; and monitoring students’ learning process. The final category of teacher behaviors consists of four components: asking higher-order questions; asking extended questions; requesting explanations for answers; and encouraging cooperative learning and conducting discussions (Facione et al., 1995; Gallini, 1989; Garcia & Pintrich, 1992; Haneghan & Stofflett, 1995; Kluger & DeNisi, 1996; Larson, 2000; McBride & Knight, 1993; Michelli et al., 1990; Udall & Daniels, 1991).

2.2. Interventions for provoking reflective teaching

Increasing self-awareness and provoking mindful learning can be two effective interventions that provoke reflective teaching. From the perspective of cognitive processing, Tillema (2000) has pointed out that metacognitive awareness lays the foundation for reflection. In a similar vein, Trapnell and Campbell (1999) attest to the theory that self-conscious people tend to reflect on their motives and goals on a regular, on-going basis. From a more practical point of view, Collier (1998) suggests that, for teacher growth, building a high level of self-awareness on the part of teacher-trainees before they participate in student teaching is critical not only to their learning of reflective teaching but also to their being able to become thoughtful practitioners. Besides this, Titone et al. (1998) have claimed that giving feedback to increase self-awareness and that encouraging “mindfulness” toward learning are effective ways to foster reflective teaching. For these reasons, interventions for provoking self-awareness and mindful learning were incorporated into the CS-TGCTS program, thereby maximizing the effectiveness of reflective teaching.

When it comes to how reflective teaching can actually contribute to improvements in professional knowledge and teacher behaviors, Trapnell and Campbell’s (1999) conclusion provides a solid psychological base for the relationship between self-reflection and knowledge construction: they state that an individual’s regular reflection on his /her motives and goals contributes to his/her reconstruction of knowledge, and thus performance. Extending this psychological viewpoint to a more practical teacher-training setting, Yeh (1999) has likewise shown that in a 32-hour training course, the self-evaluation of teacher behaviors contributes to novice teachers’

enhanced self-awareness in their teacher behaviors, which, in turn, increases their mindful learning of professional knowledge and subsequently brings about great improvements in their classroom performance. Recently, Yeh, Chen, and Chung (2001) have gone on to point out that teachers' professional knowledge seems to have a strong impact on both their own pedagogical development and their use of effective teacher behaviors.

On account of these research findings, the following hypothesis was proposed in this study: provoking self-awareness of teacher behaviors and increasing mindful learning of professional knowledge should contribute to preservice teachers' employment of reflective teaching, which should, in all likelihood, be witnessed in their improvements in teacher behaviors.

3. Method

3.1. Participants

The participants were 149 (50 males and 99 females) preservice teachers enrolled in a two-year teacher education program at National Sun Yat-sen University, Taiwan. They were in the first year of the two-year program to prepare themselves to become qualified secondary-school teachers. Their mean age was 22.98 years ($SD = 3.30$).

3.2. Instrumentation

The main instrument employed in this study was the *Computer Simulation for Teaching General Critical-Thinking Skills* (CS-TGCTS). The CS-TGCTS simulation, developed by Visual Basic 6.0, was designed to improve teachers' reflective teaching during critical-thinking instruction. The CS-TGCTS is made up of two integrated serial simulations, with each simulation taking about 2 hours to complete. More specifically, the CS-TGCTS consists of five sessions: providing background information, completing questionnaires, performing classroom teaching, receiving treatments, and receiving debriefing. The "classroom teaching" session includes four main teaching activities: arranging student location, giving an advance organizer, teaching lesson contents, and evaluating student performance. Fig. 1 depicts the instructional design of the CS-TGCTS, and an example of one of the classroom teaching sessions is shown in Fig. 2.

The CS-TGCTS simulation also provides records for measures of professional knowledge and teacher behaviors pertaining to critical thinking. Here, professional knowledge was measured with the *Questionnaire of Professional Knowledge for Critical-thinking Instruction* (QPK-CTI). QPK-CTI scores indicate participants' self-evaluation of their own professional knowledge in teaching critical thinking. With a Cronbach's α coefficient of 0.95 (9 items) (Yeh, 1999), the QPK-CTI measures two factors: content knowledge about critical thinking and pedagogical content knowledge about critical thinking. The item response options are "totally disagree," "disagree," "slightly disagree," "partly agree," "agree," and "totally agree."

The measures for teacher behaviors in the CS-TGCTS were adapted from *The Checklist for Teacher Behaviors in Critical-thinking Instruction*, CTB-CTI (Yeh, 1999). CTB-CTI scores indicate the frequency of a teacher's use of positive behaviors in teaching critical thinking. Due to technical limitations in the program design, only 12 of the 21 items in the original CTB-CTI were

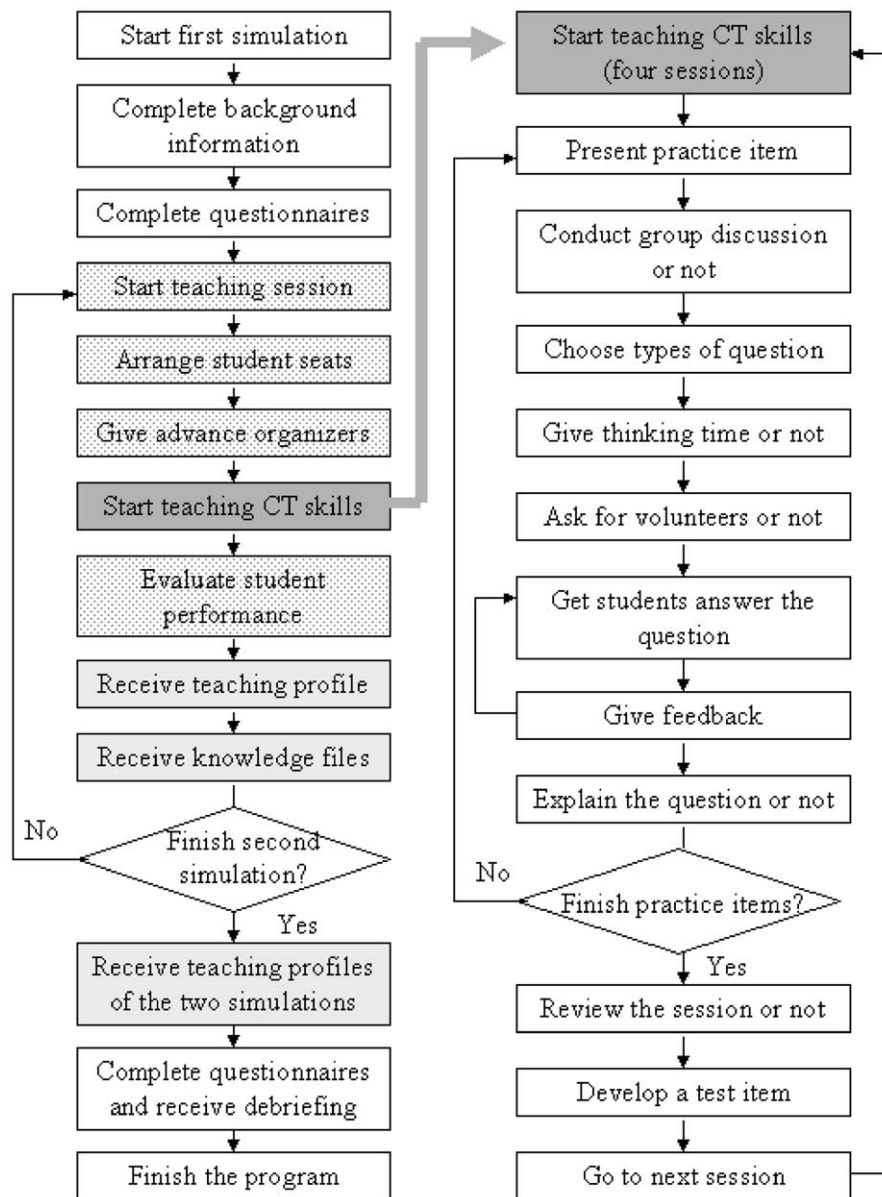


Fig. 1. Flow chart of the CS-TGCTS.

selected for use in the CS-TGCTS. In addition, the adapted CTB-CTI scores rank the percentages rather than measure the frequency of use of the 12 teacher behaviors. The Cronbach's α coefficient for the adapted CTB-CTI is 0.85 (Yeh, 1999). In the CS-TGCTS simulation, the factors that measured teacher behaviors are three-fold: expanding students' prior knowledge, upgrading their critical-thinking dispositions, and cultivating their critical-thinking skills.



Fig. 2. Screen exemplifying a classroom teaching session.

3.3. Experimental design

This study employed a pretest-posttest control group design with the participants randomly assigned to one of three experimental groups (Groups B, C, and D) or to the control group (Group A). Two types of treatment were incorporated in the CS-TGCTS program in order to provoke mindful learning (Type I) and self-awareness (Type II). Type I included five text files of research-based literature concerning professional knowledge for teaching critical thinking, while Type II treatment was comprised of a personalized bar chart depicting each individual participant's usage rate of each of the teacher behaviors during the first simulation. The treatments were given in a variety of ways depending on group membership at the completion of the first simulation. Group A received neither of the treatments, Group B received Type I treatment, Group C received Type II treatment, and Group D received both.

The basic assumption behind the experimental design was that at the completion of the simulation program, those who received both types of treatment (Group D) would have acquired the ability to perform reflective teaching and, therefore, would employ more positive teacher behaviors than those who received only one of the treatments and, of course, more than those who

received neither of the treatments. The hypothesis of the instructional design for Group D is shown in Fig. 3.

3.4. Procedures

After receiving a brief introduction to the CS-TGCTS simulation and a 10-minute demonstration by the teacher trainer, the participants each had a ten-minute practice session with the CS-TGCTS in a computer laboratory. As all participants had become familiar with the comments provided by the CS-TGCTS, they started to perform the first teaching simulation without any time limit imposed. One week later, as scheduling permitted, the participants returned to the computer laboratory and performed their second teaching simulation. The one-week interval was due to limitations with respect to the availability of the computer lab and the participants' schedules. One week was required for 149 participants to finish the first simulation.

3.5. Analyses

Descriptive statistics were employed to analyze the demographics of the participants. Several one-way multivariate analysis of covariance (MANCOVA) and univariate analysis of covariance (ANCOVA) were used to examine gender as well as group changes with regard to professional knowledge and teacher behaviors.

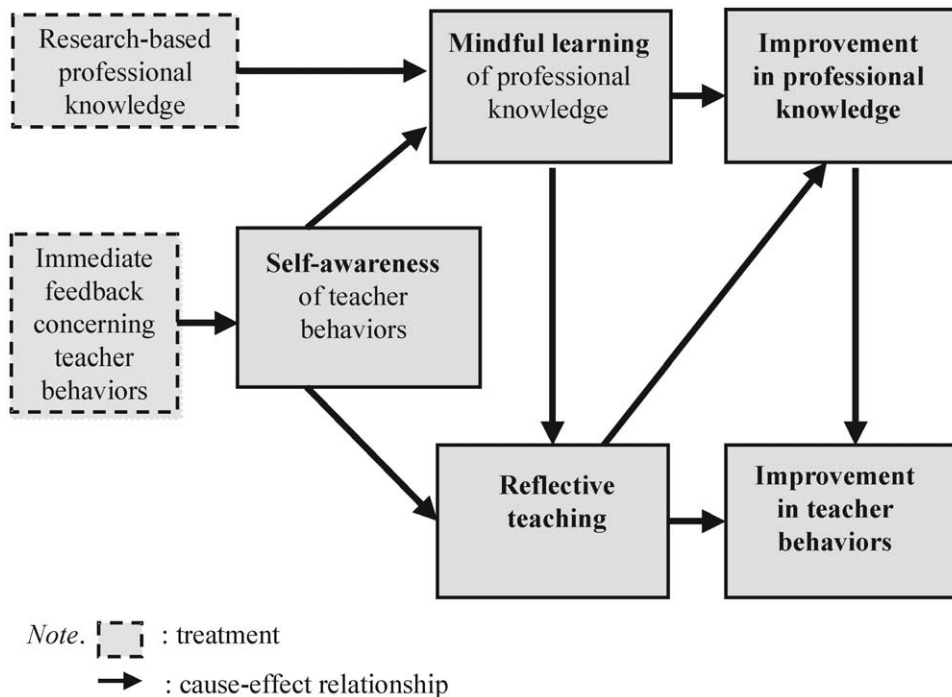


Fig. 3. Hypothesis of the instructional design for Group D.

4. Results

4.1. Average time used for simulation and gender differences

On average, the participants spent 80.93, 59.68, and 138.81 min to complete the first, the second, and the whole simulation program, respectively. No gender differences were found in terms of changes in either professional knowledge ($\Lambda = 0.99$) or teacher behaviors ($\Lambda = 0.997$), which revealed that the CS-TGCTS was not gender-biased.

4.2. Group differences in professional knowledge

Fig. 4 displays the group means of the QPK-CTI scores for the pretest and posttest. The results of MANCOVA yielded a significant group effect on professional knowledge ($\Lambda = 0.88$, $p < 0.01$). The subsequent ANCOVAs which followed resulted in a significant group effect on content knowledge, $F(3, 143) = 4.10$, $p < 0.01$, but not on pedagogical content knowledge, $F(3, 143) = 0.38$, $p = 0.77$ (see Table 1). Comparisons of the least-square means revealed that Group B and Group D who both received treatment related to professional knowledge acquired more content knowledge than did the control group, $ps < 0.05$ (see Table 2).

4.3. Group differences in teacher behaviors

Fig. 5 displays the group means of the teacher behavior scores for the pretest and posttest. The results of MANCOVA yielded a significant group effect on teacher behaviors ($\Lambda = 0.82$, $p < 0.001$). The subsequent ANCOVAs which followed resulted in significant group effects on all aspects of teacher behaviors, $F_s(3, 142) = 3.93$, 4.74, and 4.33, $ps < 0.01$ (see Table 3). Comparisons of the least-square means revealed that Group D outperformed the other groups in terms of teacher behaviors regarding expanding prior knowledge ($ps < 0.05$); Group C and Group D both outperformed the control group, and Group D outperformed Group B in teacher behaviors for upgrading critical-thinking dispositions ($ps < 0.05$); Group C and Group D again outperformed the control group in teacher behaviors for cultivating critical-thinking skills ($ps < 0.01$) (see Table 4). Moreover, comparisons of the total CTB-CTI mean scores in the posttest revealed that

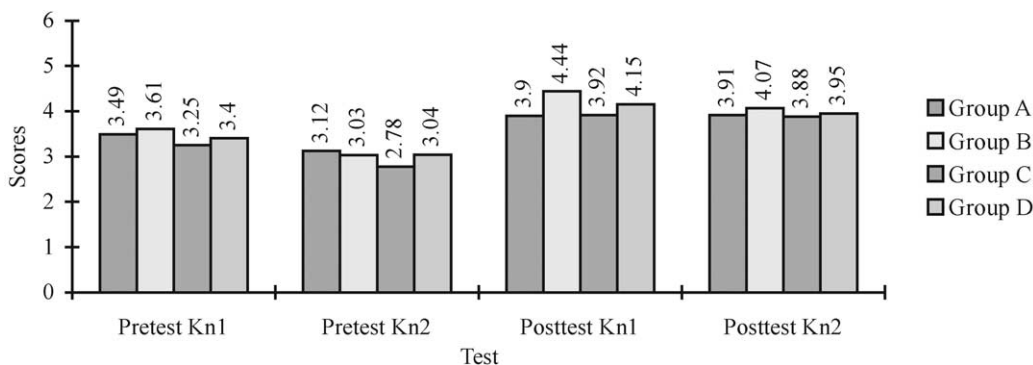


Fig. 4. Group means of the QPK-CTI scores.

Table 1
MANCOVA of group effects on the increase in professional knowledge ($N = 149$)

Variance	MANCOVA		ANCOVA $F(1, 143)$	
	df	Λ	Posttest Kn1	Posttest Kn2
Group	3	0.88**	4.10**	0.38
Covariance				
Pretest Kn1	1	0.85***	24.24***	6.48*
Pretest Kn2	1	0.90***	5.43*	15.67***
Error	143			
Total	148			

Kn1: content knowledge about critical thinking; Kn2: pedagogical content knowledge about critical thinking.

* $p < 0.001$. ** $p < 0.01$. *** $p < 0.001$.

Table 2
Comparisons of the adjusted means for the increase in professional knowledge ($N = 149$)

Variance	Group	M	SD	Least-square mean (LSM)	Standard error of LSM	Significance of mean difference
Kn1	A	3.90 (3.49)	0.71 (0.85)	3.85	0.11	B > A ($p < 0.001$)
	B	4.44 (3.61)	0.78 (1.07)	4.36	0.11	D > A ($p < 0.05$)
	C	3.92 (3.25)	0.89 (1.07)	4.03	0.10	B > C ($p < 0.05$)
	D	4.15 (3.40)	0.77 (0.89)	4.15	0.10	
Kn2	A	3.91 (3.12)	0.92 (0.94)	3.85	0.12	<i>ns.</i>
	B	4.07 (3.03)	0.98 (1.08)	4.01	0.12	
	C	3.88 (2.78)	0.82 (0.98)	3.99	0.11	
	D	3.95 (3.04)	0.81 (1.00)	3.94	0.11	

Note. Kn1: content knowledge about critical thinking; Kn2: pedagogical content knowledge about critical thinking. Number of participants in Groups A, B, C, and D are, respectively, 32, 32, 40, and 45. The means and standard deviations outside the parentheses are posttest scores, whereas those inside are pretest scores.

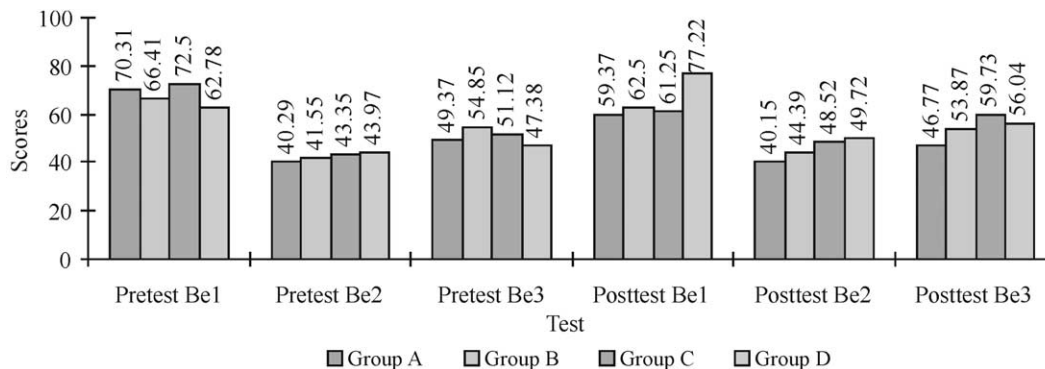


Fig. 5. Group means of teacher behavior scores.

Table 3
MANCOVA of group effects on the increase in teacher behaviors ($N = 149$)

Variance	MANCOVA		ANCOVA $F(3, 142)$		
	<i>df</i>	Λ	Posttest Be1	Posttest Be2	Posttest Be3
Group	3	0.82***	3.93**	4.74**	4.33**
Covariance					
Pretest Be1	1	0.88***	19.59***	1.53	1.06
Pretest Be2	1	0.86***	4.16*	21.68***	1.20
Pretest Be3	1	0.86***	2.35	2.69	23.36***
Error	142				
Total	148				

Note. Be1: teacher behaviors in expanding prior knowledge; Be2: teacher behaviors in upgrading critical-thinking dispositions; and Be3: teacher behaviors in cultivating critical-thinking skills.

* $p < 0.001$. ** $p < 0.01$. *** $p < 0.001$.

Table 4
Comparisons of adjusted means for the increase in teacher behaviors ($N = 149$)

Variance	Group	<i>M</i>	SD	Least-square Mean (LSM)	Standard error of LSM	Significance of mean difference
Be1	A	59.38 (70.31)	36.89 (24.95)	59.90	5.56	D > A ($p < 0.01$)
	B	62.50 (66.40)	34.78 (25.09)	62.43	5.60	D > B ($p < 0.05$)
	C	61.25 (72.50)	39.61 (21.03)	58.33	4.95	D > C ($p < 0.01$)
	D	77.22 (62.78)	29.59 (31.36)	79.45	4.75	
Be2	A	40.15 (40.29)	10.96 (8.18)	41.17	1.80	D > A ($p < 0.01$)
	B	44.39 (41.55)	8.62 (8.12)	44.44	1.81	D > B ($p < 0.001$)
	C	48.52 (43.35)	14.00 (10.50)	47.86	1.60	D > B ($p < 0.05$)
	D	49.72 (43.97)	10.96 (9.37)	49.55	1.54	
Be3	A	46.77 (49.37)	18.66 (13.67)	47.46	2.65	C > A ($p < 0.001$)
	B	53.87 (54.85)	15.70 (11.54)	52.15	2.67	D > A ($p < 0.01$)
	C	59.73 (51.12)	17.31 (18.24)	59.04	2.36	
	D	56.04 (47.38)	15.17 (15.16)	57.39	2.26	

Note. Be1: teacher behaviors in expanding prior knowledge; Be2: teacher behaviors in upgrading critical-thinking dispositions; and Be3: teacher behaviors in cultivating critical-thinking skills. Number of participants in Groups A, B, C, and D are, respectively, 32, 32, 40, and 45. The means and standard deviations outside the parentheses are posttest scores, whereas those inside are pretest scores.

Group D outperformed all of the other groups, $F(3, 142) = 6.17, p < 0.001$; the mean scores for the four groups (A, B, C and D) were 48.77, 53.59, 56.50, and 60.99, respectively. It is clear that Group D who experienced both types of treatment showed the best improvements in teacher behaviors.

5. Discussion and conclusions

5.1. *Intervention effects for provoking reflective teaching*

Two assumptions were made in this study. First, it was assumed that self-awareness and mindful learning would be two crucial mechanisms for reflective teaching; second, the claim was made that preservice teachers' use of reflective teaching would be apparent in the positive changes in their professional knowledge and, especially, in their teacher behaviors. To verify these arguments, two treatments that focused on increasing self-awareness and mindful learning were employed in the CS-TGCTS simulation. It was anticipated that Group D who had received both the treatments would have been more likely to engage in reflective teaching and, as a consequence, would have shown marked improvements in their teacher behaviors at the completion of the CS-TGCTS simulation. As expected, Group D did benefit the most from the computer-simulated training, as evidenced by the fact that their teacher behaviors had improved significantly and that they outperformed their control group counterparts in all aspects of teacher behaviors.

Although Group C who had only received the teaching profile showed greater improvement in their teacher behaviors than did both the control group and Group B, they did not improve their teacher behaviors as much as Group D. This suggests that enhancing self-awareness of teacher behaviors along with mindful learning of professional knowledge among teacher trainees has a powerful effect on generating reflective teaching and bringing about more marked behavioral changes. The results of this study, therefore, support previous findings that appropriate feedback increases self-awareness (Yeh, 1999), that self-awareness and mindfulness contribute to nurturing reflective practice (Collier, 1998; Tillema, 2000; Titone et al., 1998), and that reflective teaching is built upon background knowledge (Rodriguez & Sjostrom, 1998). The findings here also support the argument that effective reflective teaching is enhanced through a cyclic process in which professional knowledge is gained through reflection while practicing and then the improved professional knowledge carries insight back into the practice of teaching (Loughram, 2002).

To sum up, the aforementioned results serve as conclusive evidence of the great influence of reflective teaching on professional growth, evidence of the necessity of self-awareness and mindful learning in bringing about reflective teaching, and evidence of the importance of immediate feedback on reflective teaching in a computer simulation program. Moreover, from the study findings, it is reasonable to conclude that greater advances with respect to reflective teaching occur when interventions to improve professional knowledge and teacher behaviors are employed concurrently.

5.2. *Knowledge improvement in the CS-TGCTS*

This study integrated two types of professional knowledge, namely content knowledge and pedagogical content knowledge, into the CS-TGCTS simulation. It was anticipated that preservice

teachers would become more knowledgeable about the effective instruction of critical thinking and, therefore, would impart greater reflectivity in their own personal teaching practices. Though it contributed to reflective teaching, this particular design did not bring about as satisfactory of an outcome as predicted. More specifically, the CS-TGCTS simulation was effective in improving preservice teachers' content knowledge, but not their pedagogical content knowledge. Therefore, while this supports [Rodriguez and Sjostrom's \(1998\)](#) claim that reflective teaching is built upon a teacher's existing knowledge, the findings in this study are not consistent with [Ormrod and Cole's \(1996\)](#) claim that both teachers' content knowledge and pedagogical content knowledge can be enhanced effectively in a short-term training program.

The insignificant improvement in pedagogical content knowledge among participants in this study can most likely be attributed to the fact that pedagogical content knowledge, which encompasses teachers' responses to students with different needs in specific domains, addresses a much broader scope of understanding than simple content knowledge ([Yeh, 1997](#)). An alternative explanation might be that the instructional design of the CS-TGCTS focuses more on the acquisition of content knowledge than on pedagogical content knowledge. Case-based discussions ([Abell et al., 1998](#)) and practical arguments both of which provide means to understand and explain particular actions ([Boody, East, Fitzgerald, Helson, & Iverson, 1998](#)) can be effective methods to improve pedagogical content knowledge. Future program designers can consider incorporating these pedagogies into a simulation program.

In addition, that there were much stronger group effects on teacher behaviors than on professional knowledge seems to suggest that the interventions employed in this study contributed more to the preservice teachers' improvements in teacher behaviors than in professional knowledge. This finding is actually consistent with the instructional design of the CS-TGCTS program (see [Fig. 3](#)); that is, as the final goal, all interventions were employed to bring about behavioral change. However, as teachers' professional knowledge serves as the basis for reflective practice ([Abell et al., 1998](#); [Loughram, 2002](#); [Trapnell & Campell, 1999](#)), if more efforts are put toward increasing teachers' knowledge during their training, the capacity to improve reflective teaching may increase as well.

5.3. *Conclusions*

Nurturing reflective teaching is fundamental to the success of teacher education ([Kahne & Westheimer, 2000](#); [Larson, 2000](#)) and the ultimate goal of emphasizing reflective teaching is for teachers to gain a deeper understanding of their teaching practices so that they can improve them ([Abell et al., 1998](#)). In the endeavor to help preservice teachers to habitually practice reflective teaching and become competent in critical-thinking instruction, the CS-TGCTS simulation was developed. The findings in this study suggest that the CS-TGCTS simulation is an effective tool for improving preservice teachers' reflective teaching in critical-thinking instruction. In addition, the instructional design of the CS-TGCTS can serve as a valuable reference source in teacher education programs which strive to cultivate more reflective teachers. Finally, the simulation's educational benefits are strongly related to its capacity to enhance professional knowledge coupled with its ability to provide an analytical yet highly supportive environment for practicing teaching skills.

Acknowledgements

This research was supported in part by National Science Council, Taiwan under the grant NSC90-2520-S-110-001.

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