Aptitude-treatment interactions in preservice teachers' behavior change during computer-simulated teaching

Yu-Chu Yeh

Institute of Teacher Education, Center for Creativity and Innovation Studies, National Chengchi University, 64, Chih-nan Road, Sec. 2, Wenshan, Taipei 116, Taiwan

Received 12 January 2004; accepted 10 March 2005

Abstract

Adapting training methods to specific teacher traits to best facilitate the training effects for preservice teachers is an important, yet neglected, topic in aptitude-treatment interaction research. This study investigated interactions between four personal traits (CT-dispositions, thinking styles, CT-skills, and intrapersonal intelligence) and two designed treatments on preservice teachers' behavior change during a computer-simulated teaching experience. One hundred and seventy-eight preservice teachers participated in this study. The CS-TGCTS simulation program was employed to measure the preservice teachers' actual use of effective teacher behaviors, as well as the four targeted personal traits which were measured by three Likert-scale inventories and one multiple-choice test. The results suggest that preservice teachers with high levels of CT-dispositions, CT-skills, and intrapersonal intelligence – as well as those with judicial or legislative thinking styles – are mindful, analytical, and reflective in their teaching practices and therefore more likely to continually improve their teaching skills.

Keywords: Architectures for educational technology system; Improving classroom teaching; Interactive learning environments; Simulations; Teaching/learning strategies.

1. Introduction

When incorporating computers into teacher training, teacher educators must consider teachers' personal traits, because aptitude-treatment interactions (ATIs) influence the course and outcomes of training. The evaluation of ATIs must go beyond merely assessing the interactions among individuals and situational variables; ATIs offer a framework for new theories of aptitude interpreted as personal readiness to profit from particular treatment situations (Snow, 1991). Consequently, teachers with certain traits benefit more from a specific teacher-training method than do those who lack those traits.

Because many researchers have suggested that computer simulation is an effective tool for teacher training (Charischak, 2000; Haneghan & Stofflett, 1995; Kenny, Covert, Schilz, Vignola, & Andrews, 1995; Yeh, 2004) and because critical thinking has been regarded as a new teaching standard (Birman, Desimone, Porter, & Garet, 2000; Darling-Hammond, 1999), a computer simulation for critical-thinking instruction was employed in this study to investigate the ATI effects on preservice teachers' behavior change. Briefly speaking, this study attempted to understand whether certain preservice teachers' personal traits interact with specific treatments in a simulation program to influence the improvement of effective teacher behaviors in critical-thinking instruction. In this study, four personal traits were of particular interest: critical-thinking dispositions (CT-dispositions), thinking styles, critical-thinking skills (CT-skills), and intrapersonal intelligence.

2. Personal traits and changes in teacher behaviors

2.1. Effective teacher behaviors and mechanisms for their improvement

Teachers' behavior change in critical-thinking instruction was the dependent variable in this study. Drawing upon previous research findings (e.g., Facione, Sanchez, Facione, & Gainen, 1995; Garcia & Pintrich, 1992; Halpern, 1998; Haneghan & Stofflett, 1995; Harris & Eleser, 1997; Kluger & DeNisi, 1996; Larson, 2000; McBride & Knight, 1993; Michelli, Pines, & Oxman-Michelli, 1990; Udall & Daniels, 1991), I defined the variable in terms of 12 effective teacher behaviors in CT instruction that fall within three categories of intent. The first category involves increasing students' prior knowledge. Related teacher behaviors include (a) providing students with advance organizers and (b) providing students with review sessions. The second category focuses on enhancing students' critical-thinking dispositions. Related behaviors include (c) keeping students focused on tasks or discussions, (d) giving ample time for thinking, (e) allowing a variety of student answers, (f) giving cues when students cannot answer correctly, (g) giving positive feedback, and (h) monitoring the students' learning process. The final category is upgrading students' critical-thinking skills, and related behaviors are (i) asking higher-order questions, (j) asking extended questions, (k) requesting explanations for answers, and (l) encouraging cooperative learning and conducting discussions. These 12 teacher behaviors were measured in the simulation program employed in this study.

Previous studies have suggested that self-awareness and mindfulness contribute to nurturing reflective practice (Collier, 1999; Tillema, 2000; Titone, Sherman, & Palmer, 1998), and they bring

about remarkable improvements in teacher behaviors (Yeh, 2004). Reflective teaching refers to instructors' purposeful and systematic inquiry into their own personal theories of teaching and learning, as well as into the practices dictated by those theories (Abell, Bryan, & Anderson, 1998). Such reflection maximizes a teacher's creative ability to improve his or her teaching practices (Collier, 1999; Rodriguez & Sjostrom, 1998; Titone et al., 1998). Accordingly, mindful learning, self-awareness, and reflective teaching are crucial mechanisms that lead to the improvement of teacher behaviors. Four personal traits (two personality characteristics and two abilities) that may interact with these mechanisms and result in behavior change are discussed in the following sections.

2.2. Teacher personalities and behavior change

This study investigated, in part, teachers' CT-dispositions and thinking styles. CT-dispositions refer to attitudes, commitments, and tendencies for thinking critically (Norris & Ennis, 1989). They involve such qualities as open-mindedness, intellectual curiosity, reflective thinking, and being analytical and systematic in problem solving (Bailin, Case, Coombs, & Daniels, 1999; Facione et al., 1995; Halpern, 1997; McBride & Knight, 1993; Paul & Elder, 2001). More specifically, CT-dispositions include (a) a willingness to engage in, and persist at, a complex task, (b) habitual use of plans and the suppression of impulsive activity, (c) flexibility or open-mindedness, (d) a willingness to abandon nonproductive strategies in an attempt to self-correct, and (e) an awareness of the social realities that need to be overcome so that thoughts can become actions (Halpern, 1998).

Yeh (1997) found that CT-dispositions are related to mindful learning and self-awareness; they therefore contribute to preservice teachers' professional growth. Moreover, research findings (Facione et al., 1995) have suggested that a person's dispositions toward critical thinking are significantly related to his or her ego-resiliency, which refers to a person's ability to change his or her model of perceptual and behavioral functioning in order to adapt to situational constraints. Accordingly, teachers with strong CT-dispositions are aware of their behaviors, open-minded and mindful in learning, and reflective and self-regulated in teaching; thus, they are able to improve their skills during a training session.

Thinking style relates to one's mental self-government; and individuals prefer to use their intellectual abilities for certain functions, which gives them a characteristic thinking style (O'Hara & Sternberg, 2000–2001). More specifically, thinking style is the preferred way of expressing or using one's intellectual abilities; it is related to how a person chooses to exploit knowledge and decide how to use it in day-to-day interactions with the environment (Sternberg, 1994, 1997; Zhang & Sternberg, 2000). Sternberg (1988) proposed 13 thinking styles grouped together within five aspects: functions, forms, levels, domains, and learnings (Cano-Garcia & Hughes, 2000; Sternberg, 1988, 1997). This study focused only on functions. Three functions are legislative, executive, and judicial styles (Sternberg, 1997). People with a legislative style prefer to do things their own way and to build their own structures when deciding how to approach a situation or a problem; they prefer creative and constructive planning-based activities. Individuals with a judicial style like to evaluate rules and procedures and analyze and evaluate existing rules; they prefer activities that exercise the judicial functions. An executive style is seen in those who prefer pre-structured tasks; they like activities that are already defined for them (Sternberg, 1997; Zhang & Sternberg, 2000).

Several researchers (Chang, 1998; Sternberg, 1997; Zhang, 2001) have suggested that thinking styles relate to teaching efficacy, teaching approaches, and teaching behaviors. For example,

Zhang (2001) found that teachers with judicial or legislative thinking styles tend to employ a student-focused approach or a conceptual-change approach. Such teaching approaches emphasize students' intellectual autonomy and the chance to make decisions. Furthermore, preservice teachers with judicial thinking styles tended to be most analytical in their teaching behavior; those with executive thinking styles were the least analytical (Sternberg, 1997). Constructivist teaching approaches and the characteristics of judicial and legislative thinking styles align with the positive teacher behaviors of critical-thinking instruction; they are required if teachers are to be self-reflective about their behaviors.

2.3. Teacher abilities and behavior change

Two types of teacher abilities were studied here: CT-skills and intrapersonal intelligence. Critical thinking is a purposeful, goal-directed, and self-regulatory thinking process; it requires a set of dispositions as well as skills (Norris & Ennis, 1989). CT-skills are different from CT-dispositions in that the former concern "cognitive abilities", while the latter involve "affective attitudes". CT-skills involve both cognitive and metacognitive skills such as analysis, interpretation, inference, evaluation, induction, deduction, judgment of credibility, identification of assumption, self-monitoring, self-regulation, and self-evaluation (Browne & Meuti, 1999; Gadzella & Masten, 1998; Halpern, 1998; Hittner, 1999; Lawson, 1999; McCarthy-Tucker, 2000; Paul & Elder, 2001). Norris and Ennis (1989) indicated that a good critical thinker must possess skills for establishing comprehensive support, obtaining clarification, drawing inferences, and applying strategies. Beyond pointing out a set of skills, Halpern (1998) proposed a taxonomy for CT-skills: (a) verbal reasoning, (b) argument analysis, (c) hypothesis testing, (d) using likelihood and uncertainty, and (e) decision making and problem solving.

CT-skills are a form of rational thinking, and research findings have suggested that rational information processing is positively related to adaptation (Epstein, Pacini, & Heier, 1996). When people think critically, they are not only evaluating their thinking process; they are also providing useful and accurate feedback that serves to improve their thinking process (Halpern, 1996, 1998). Consequently, teachers with good CT-skills are likely to be analytical and reflective about their teaching and to make good use of feedback given during the training process. As a result, they can adapt their teacher behaviors.

Intrapersonal intelligence has been broadly defined as the capacity to self-reflect: to be aware of the strengths and weaknesses, feelings, and thought processes that constitute one's knowledge of self (Furnham, Tang, Lester, O'Connor, & Montogomery, 2002; Gardner, 1999; Shepard, Fasko, & Osborne, 1999). Moreover, intrapersonal intelligence is closely related to goal setting, thinking skills, emotional expression, and self-directed learning (Campbell, Campbell, & Dickinson, 1999); it is associated with one's ability to identify problems and to undertake deep introspection (Armstrong, 2000; Harman & Rheingold, 1984).

Intrapersonal intelligence also features in problem-solving endeavors with significance for the individual (Gardner, 1993, 1999). It is related to strategic processing of executive control: the ability to reflect upon and regulate one's thoughts and behaviors (Campbell et al., 1999; Gardner, 1993; Shepard et al., 1999). In addition, it encompasses a form of self-awareness that goes beyond the strict demands of selecting strategies and evaluating outcomes in the problem-solving process (Shepard et al., 1999). Mitina and Kuz'menkova (1999) found that teachers with a high level of

professional self-awareness can move outside the boundaries of everyday and routine pedagogical practice. Such strategic processing abilities and self-awareness are clearly essential to learning and professional development, especially for the improvement of teaching practices.

2.4. Hypothesis

The following hypothesis was proposed in the present study: preservice teachers' personal traits interact with the designed treatments in the CS-TGCTS simulation program in ways that affect the outcome as defined in terms effective teacher behaviors. The designed treatments emphasized being mindful in learning, self-aware in teacher behaviors, and reflective in teaching practices. These emphases were the key mechanisms for the attribute-treatment interactions in the CS-TGCTS. Specifically, preservice teachers with high levels of CT-dispositions, CT-skills, and intrapersonal intelligence were expected to improve their teacher behaviors significantly as a result of the CS-TGCTS simulation program, while their counterparts with low levels of those personal traits were expected to benefit less. In addition, those with judicial or legislative thinking styles were expected to improve their teacher behaviors after the computer-simulation training, whereas those with executive thinking styles would improve less or not at all.

3. Methods

3.1. Participants

The participants were 51 male (28.7%) and 127 female (71.3%) preservice teachers enrolled in a two-year teacher education program at the National Sun Yat-sen University, Taiwan. They were preparing to be qualified as secondary-school teachers. With a mean age of 23.90 years (SD = 3.67), the largest group was that between 21 and 25 years old (82.6%), and the mode was 23 years.

3.2. Instruments

The participants' interactive teaching experience in this study was accomplished via Computer Simulation for Teaching General Critical-Thinking Skills, CS-TGCTS (Yeh, 2004). The CS-TGCTS comprised two integrated serial simulations, each simulation taking about 2 h to complete. Twelve teacher behaviors were measured in the CS-TGCTS simulation. The measured scores indicated the percentages of a teacher's actual usage of teacher behaviors pertaining to improving students' prior knowledge, CT-dispositions, and CT-skills. The CS-TGCTS simulation also provided records for measurements of the participants' thinking styles, CT-dispositions, intrapersonal intelligence, and CT-skills. The employed instruments for these teacher traits were the Inventory of Critical Thinking Dispositions (ICTD), the Inventory of Thinking Styles (ITS), the Questionnaire of Intrapersonal Intelligence (QII), and the Critical Thinking Test, Level II (CTT-II). The first three inventories were Likert-type scales; the fourth was a multiple-choice test.

With a total of 20 items, the ICTD comprised four factors: systematicity and analyticity (nine items), open-mindedness (four items), intellectual curiosity (three items), and reflective thinking

(four items). ICTD was a 6-point Likert scale anchored from "never" to "always". The Cronbach's α coefficients for all items and the four factors were .88, .83, .58, .70, and .63, respectively. The correlations among the four factors were $rs(98) = .31–.60$ ($ps < .01$) (Yeh, 1999). The QII, a 6-point Likert scale anchored from "totally disagree" to "totally agree", was adapted from Armstrong's checklist of intrapersonal intelligence. The QII contained only one factor and its Cronbach's α coefficient was .80 (seven items) (Chu, 2001). The ITS, a 5-point Likert scale anchored from "never" to "always", was adapted from the Sternberg-Wagner Thinking Styles Inventory (Li, 1999). With a total of 15 items, the three thinking styles included in this inventory were judicial, legislative, and executive style. The Cronbach's α coefficients for all items and for the three styles were .80, .69, .62, and .61, respectively.

The CTT-II, which comprised 25 multiple-choice items, was divided evenly into five subtests: assumption identification, induction, deduction, explanation, and argument evaluation (Yeh, 2001). Each item contained one statement and four multiple-choice answers. The time limit was 20 min, which was automatically timed in the simulation. The mean discriminate index of CTT-II was .53; its mean difficulty index was .58. The correlations between the subtest scores and the total score were $rs(185) = .59–.69$, $ps < .01$.

3.3. Procedures and instructional design

All participants enrolled in Educational Psychology took the CS-TGCTS simulation in a computer laboratory as part of their class requirements. After receiving a brief introduction to the simulation and a 10-min demonstration by the teacher trainer, the participants had a 10-min practice session with the CS-TGCTS. After participants had become familiar with the components of the CS-TGCTS, they began 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 a result of the limited availability of the computer lab and the participants' schedules.

The first simulation consisted of the following sessions presented sequentially: background information, inventories, classroom teaching, and treatments; the second simulation comprised classroom teaching and debriefing. The classroom teaching session included four main teaching activities: arranging student location, giving an advance organizer, teaching lesson content, and evaluating student performance. Two types of treatments were incorporated in the CS-TGCTS program to promote mindful learning of professional knowledge, self-awareness of teacher behaviors, and reflective teaching (Yeh, 2004). The Type I treatment included five text files of research-based the literature on teaching critical thinking. The Type II treatment comprised a personalized bar chart depicting each participant's actual usage rate of each teacher behavior during the first simulation. Fig. 1 shows an example of the bar graph provided to each participant in the Type II treatment. While the pretest scores of the teacher behaviors were obtained from the first simulation, the posttest scores of teacher behaviors were collected from the second simulation.

3.4. Analyses

Several Repeated Measures Analyses of Variance were performed to test gender effects and the effects of the four independent variables (CT-dispositions, thinking styles, CT-skills, and

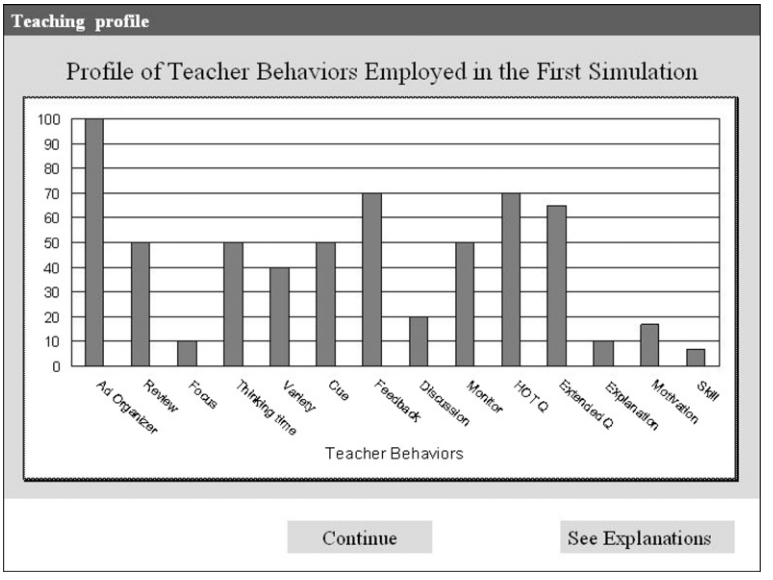

Fig. 1. Example of the graph provided to individual participants in the Type II treatment. *Note*: Ad. Organizer, provide advance organizers; Review, provide review session; Focus, keep students focused on undertaking tasks or discussions; Thinking time, give time for thinking; Variety, allow a variety of student answers; Cue, give cues when students cannot answer correctly; Feedback, give positive feedback; Discussion, conduct group discussions; Monitor, monitor students' discussion process; HOT Q, ask higher-order questions; Extended Q, ask extended questions; Explanation, request explanations for answers; Motivation, evaluate students' motivation in learning critical thinking; Skill, evaluate students' critical-thinking skills. The evaluation of student motivation and skills are not included in the 12 defined effective teacher behaviors, but they are part of the instructional design in the CS-TGCTS program.

intrapersonal intelligence) on the changes of the dependent variable (teacher behaviors). In these analyses, two levels of variables were used: Group and Test. The first level was the gender Group (male vs. female) or the independent variable Group (low vs. high group divided by the mean score). The second level Test was the dependent variable scores (pretest vs. posttest teacher behaviors).

4. Results

4.1. Gender differences and average time used for simulation

One Repeated Measure Analysis of Variance was employed to test gender effects on behavior change. No significant Gender (male vs. female) × Test (pretest vs. posttest) interaction effect ($\Lambda = .99$, $p = .113$) or main effect of Gender, $F(1, 175) = 0.02$, $p = .877$, on the preservice teachers' behavior change was found, which revealed that the CS-TGCTS was not gender-biased. On average, the participants took 73.69 (SD = 17.43), 53.99 (SD = 18.25), and 127.66 (SD = 32.18) minutes to complete the first, the second, and the entire simulation program, respectively.

4.2. Effects of personalities on behavior change

Four Repeated Measures Analyses of Variance were performed to examine the effects of CT-dispositions and the three thinking styles on the participants' behavior change. None of the Group (high vs. low) × Test (pretest vs. posttest) effects was significant, Λs = .99, 1.00, 1.00, .98 for CT-dispositions, judicial style, legislative style, and executive style, respectively.

However, the four analyses yielded significant main effects of Test on behavior change, $F(1,175) = 34.40$, $p < .001$ for CT-dispositions and Fs$(1,174) = 31.58, 32.36, 28.36$, $ps < .001$ for judicial, legislative, and executive style, respectively (see Tables 1 and 2). These findings indicate that the preservice teachers used more positive teacher behaviors on the posttest than on the pretest in all the analyses. Moreover, except for the executive style, $F(1,174) = 0.03$, $p = .863$, the other three main effects of Group were significant, $F(1,175) = 9.89$, $p < .01$ for CT-dispositions and Fs$(1,174) = 10.91, 5.18$, $ps < .05$ for judicial and legislative style, respectively. Comparisons of the marginal means revealed that the preservice teachers with high CT-dispositions showed greater improvement in teacher behaviors than those with low CT-dispositions. Moreover, those who were prone to the judicial and legislative thinking styles demonstrated more improvement in teacher behaviors than those who were not.

4.3. Effects of abilities on behavior change

No significant Group (low vs. high CT-skills) × Test (pretest vs. posttest) interaction effect was found in the Repeated Measures Analysis of Variance ($\Lambda = 1.00$, $p = .882$). However, there were significant main effects of Test and Group, Fs$(1,175) = 32.47, 10.71$, $ps < .001$ (see Table 3). Comparisons of the estimated marginal means revealed that the preservice teachers used more positive teacher behaviors on the posttest than on the pretest; moreover, those who had a tendency to think critically showed greater improvement in teacher behaviors than those who did not. Again, the Repeated Measures Analysis of Variance did not yield a significant Group (low vs. high intrapersonal intelligence) × Test (pretest vs. posttest) interaction effect ($\Lambda = .99$, $p = .187$); but there were significant main effects of Test and Group, Fs$(1,175) = 33.28, 3.99$, $ps < .05$ (see Table 4). Comparisons of the estimated marginal means revealed that the preservice teachers used more

Table 1
Main effects of CT-disposition Group and Test on behavior change

	N	*M*	SD	*F*(1,175)	*p*	η^2
Group						
Low	93	51.56	1.35	9.89*	.002	.05
High	84	57.71	1.42			
Test						
Pretest	177	51.10	0.98	34.40**	.000	.16
Posttest	177	58.17	1.30			

* $p < .01$.
** $p < .001$.

Table 2
Main effects of thinking-style Group and Test on behavior change

	N	*M*	SD	*F*(1, 174)	*p*	η^2
Judicial style						
Group						
Low	86	51.13	1.40	10.91**	.001	.06
High	90	57.59	1.37			
Test						
Pretest	176	50.98	0.97	31.58***	.000	.15
Posttest	176	57.74	1.30			
Legislative style						
Group						
Low	100	52.46	1.32	5.18*	.024	.03
High	76	57.03	1.51			
Test						
Pretest	176	51.29	0.99	32.36***	.000	.16
Posttest	176	58.20	1.33			
Executive style						
Group						
Low	74	54.64	1.00	0.03	.863	.00
High	102	54.29	1.35			
Test						
Pretest	176	51.24	1.00	28.36***	.000	.14
Posttest	176	57.68	1.35			

* $p < .05$.
** $p < .01$.
*** $p < .001$.

Table 3
Main effects of CT-skill Group and Test on behavior change

	N	*M*	SD	*F*(1, 175)	*p*	η^2
Group						
Low	79	50.93	1.46	10.71*	.001	.06
High	98	57.34	1.31			
Test						
Pretest	177	50.66	.97	32.47**	.000	.16
Posttest	177	57.61	1.32			

* $p < .01$.
** $p < .001$.

positive teacher behaviors on the posttest than on the pretest. In addition, those with high intrapersonal intelligence showed better improvement in teacher behaviors than their classmates who scored low on intrapersonal intelligence.

Table 4
Main effects intrapersonal-intelligence Group and Test on behavior change

	N	*M*	SD	*F*(1, 175)	*p*	η^2
Group						
Low	88	52.49	1.41	3.99*	.047	.02
High	89	56.45	1.40			
Test						
Pretest	177	50.98	0.98	33.28**	.000	.16
Posttest	177	57.95	1.32			

* $p < .05$.
** $p < .001$.

5. Discussion and conclusions

This study examined aptitude-treatment interaction effects during a computer-simulated training session in an attempt to understand whether four teacher traits (CT-dispositions, thinking styles, CT-skills, and intrapersonal intelligence) would interact with the designed treatments and influence preservice teachers' improvement of teacher behaviors during computer-simulated training. The findings support the hypothesis. Except for the executive thinking style, all targeted teacher traits had positive effects on the preservice teachers' behavior change. The CS-TGCTS program was designed to improve teacher behaviors by stimulating mindful learning, self-awareness, and reflective teaching; the significant results found in this study suggest that important ATIs occur during computer-simulation training and influence its outcomes. Positive personal traits – including CT-dispositions, judicial and legislative thinking styles, CT-skills, and intrapersonal intelligence – influence how preservice teachers learn and adapt to information, feedback, and teaching practices. Interpreting aptitudes as personal readiness to profit from particular treatment situations (Snow, 1991), this study shows that the teacher traits addressed here are important to preservice teachers' professional growth. Therefore, teacher education programs should increase their efforts to cultivate such positive teacher traits.

The findings in this study also suggest that CT-dispositions and thinking styles contribute to expert thinking, teacher behaviors, and professional growth (Sato, Akita, & Iwakawa, 1993; Sternberg, 1997; Zhang, 2001). This study found that preservice teachers with high levels of CT-dispositions showed greater improvement in teacher behaviors than those with low levels. The development of expertize in any area requires deliberate, effortful, and intense cognitive work (Wagner, 1997); not surprisingly, teaching is no exception. CT-dispositions contribute to expending mental effort toward learning how to analyze complex classroom situations (Sears & Parsons, 1991). Such conscious exertion of mental effort is essential to a teacher's professional growth.

In this study, those with a judicial thinking style benefited most from the computer-simulated training, those with legislative thinking styles closely followed, and those with executive thinking styles lagged far behind (see *F* values in Table 2). Sato et al. (1993) suggested that expert teachers are characterized by thinking styles such as sensitivity, involvement in a situation, having multiple points of view, and having a wide perspective. In addition, such expert thinking is context relevant, in that a problem-framing approach is employed in constructing and reconstructing thoughts on

teaching. From findings and suggestions concerning teachers' thinking styles (Chang, 1998; Sternberg, 1997; Zhang, 2001), we see that expert teachers' thinking and behaviors demonstrate either judicial or legislative thinking styles. These thinking styles contribute to preservice teachers' professional growth during teacher training.

In this study, preservice teachers with good CT-skills and high intrapersonal intelligence showed greater improvement in teacher behaviors. These results support earlier findings (Garcia & Pintrich, 1992; Shepard et al., 1999) that CT-skills are effective learning strategies and that intrapersonal intelligence functions as a strategic processing of executive control in problem-solving and teaching practices. Critical thinking involves the employment of cognitive and metacognitive skills that are required for self-regulation, self-assessment, and problem solving; intrapersonal intelligence concerns one's self-awareness, reflective thinking, and the abilities to analyze performance and change. These abilities are essential to reflect upon one's learning and to adapt one's behaviors to enhance student learning. A professional teacher is one who continuously learns from teaching. Accordingly, teacher educators should develop preservice teachers' capacity for being mindful, systematic, and reflective in their learning as well as in their teaching processes.

In conclusion, the findings in this study confirm the importance of four teacher traits on preservice teachers' professional growth. Positive teacher traits, such as CT-dispositions, judicial or legislative thinking style, CT-skills, and intrapersonal intelligence relate to mindful learning, self-awareness, and reflective thinking in teaching practice. They influence the improvement in teacher behaviors that can be achieved during teacher training via a computer simulation. Moreover, computer simulations, which provide valuable information for teacher preparation, have proven effective tools for understanding preservice teachers' professional growth. Further studies can identify other personal traits and mechanisms that contribute to teachers' professional growth via computer-simulated teaching programs.

Acknowledgments

This research was supported in part by the National Science Council, Taiwan; Grant No.: NSC90-2520-S-110-001. I thank Dr. Carol Tomlinson and Cindy Strickland for their comments on this article.

References

Abell, S. K., Bryan, L. A., & Anderson, M. A. (1998). Investigating preservice elementary science teacher reflective thinking using integrated media case-based instruction in elementary science teacher preparation. *Science Teacher Education, 82*, 491–509.

Armstrong, T. (2000). *Multiple intelligences in the classroom* (2nd ed.). Alexandria, VA: Association for Supervision and Curriculum Development.

Bailin, S., Case, R., Coombs, J. R., & Daniels, L. B. (1999). Common misconceptions of critical thinking. *Journal of Curriculum Studies, 31*(3), 269–283.

Birman, B. F., Desimone, L., Porter, A. C., & Garet, M. S. (2000). Designing professional development that works. *Educational Leadership, 57*(8), 28–33.

Browne, M. N., & Meuti, M. D. (1999). Teaching how to teach critical thinking. *College Student Journal, 33*(2), 162–170.

Campbell, L., Campbell, B., & Dickinson, D. (1999). *Teaching and learning through multiple intelligences*. Needham Heights, MA: Allyn and Bacon.
Cano-Garcia, F., & Hughes, E. H. (2000). Learning and thinking styles: An analysis of their interrelationship and influence on academic achievement. *Educational Psychology, 20*(4), 413–430.
Chang, Y. (1998). Thinking styles and teaching efficacy. *Elementary School Education, 38*(3), 36–41.
Charischak, I. (2000). A look at technology's role in professional development of mathematics: Teachers at the middle school level. *School Science and Mathematics, 100*(7), 349–354.
Chu, Y. Y. (2001). *The relationships between belief change and its influential factors for student teachers*. Unpublished thesis, National Sun Yat-Sen University, Taipei, Taiwan.
Collier, S. T. (1999). Characteristics of reflective thought during student teaching experience. *Journal of Teacher Education, 50*(3), 173–181.
Darling-Hammond, L. (1999). Educating teachers for the next century: Rethinking practice and policy. In G. Griffin (Ed.), *The education of teachers: Ninety-eighth year book of the National Society for the Study of Education* (pp. 221–256). Chicago: University of Chicago Press.
Epstein, S., Pacini, R., & Heier, H. (1996). Individual differences in intuitive-experiential and analytical-rational thinking styles. *Journal of Personality and Social Psychology, 71*, 390–405.
Facione, P. A., Sanchez, C. A., Facione, N. C., & Gainen, J. (1995). The dispositions toward critical thinking. *The Journal of General Education, 44*(1), 1–25.
Furnham, A., Tang, T. L., Lester, D., O'Connor, R., & Montogomery, R. (2002). Estimates of ten multiple intelligences: Sex and national differences in the perception of oneself and famous people. *European Psychologist, 7*(4), 245–255.
Gadzella, B. M., & Masten, W. G. (1998). Critical thinking and learning processes for students in two major fields. *Journal of Instructional Psychology, 25*(4), 256–261.
Garcia, T. & Pintrich, P. R. (1992, August). Critical thinking and its relationship to motivation learning strategies, and classroom experiences. *Paper presented at the meeting of the American Psychological Association*, Washington, DC.
Gardner, H. (1993). *Multiple intelligence: The theory in practice*. New York, NY: Basic Books.
Gardner, H. (1999). *Intelligence reframed*. New York, NY: Basic Books.
Halpern, D. F. (1996). *Thought and knowledge: An introduction to critical thinking* (3rd ed.). Mahwah, NJ: Erlbaum.
Halpern, D. F. (1997). *Critical thinking across the curriculum: A brief edition of thought and knowledge*. Mahwah, NJ: Lawrence Erlbaum Associates, Publishers.
Halpern, D. F. (1998). Teaching critical thinking for transfer across domains dispositions, skills, structure training, and metacognitive monitoring. *American Psychologist, 53*(4), 449–455.
Haneghan, J. V., & Stofflett, R. T. (1995). Implementation problem-solving technology into classroom: Four case studies of teachers. *Journal of Technology and Teacher Education, 3*(1), 57–80.
Harman, W., & Rheingold, H. (1984). *Higher creativity: Liberating the unconscious for breakthrough insights*. Los Angeles, LA: Jeremy P. Tarcher.
Harris, J. C., & Eleser, C. (1997). Developmental critical thinking: Melding two imperatives. *Journal of Developmental Education, 21*(1), 12–19.
Hittner, J. B. (1999). Fostering critical thinking in personality psychology: the trait paper assignment. *Journal of Instructional Psychology, 26*(2), 92–97.
Kenny, R. F., Covert, J., Schilz, M. N., Vignola, M., & Andrews, B. W. (1995). Interactive multimedia instruction to develop reflective decision-making among preservice teachers. *Journal of Technology and Teacher Education, 3*(2/3), 169–188.
Kluger, A. N., & DeNisi, A. (1996). The effects of feedback interventions on performance: A historical review, a meta-analysis, and a preliminary feedback intervention theory. *Psychological Bulletin, 119*(2), 254–284.
Lawson, T. J. (1999). Assessing psychological critical thinking as a learning outcome for psychology majors. *Teaching of Psychology, 26*(3), 207–209.
Li, C. Y. (1999). *The study of pupils' thinking styles and its correlates in Hualien elementary school*. Unpublished thesis, National Hualien Teacher's College, Hualien, Taiwan.
Larson, B. E. (2000). Classroom discussion: A method of instruction and a curriculum outcome. *Teaching and Teacher Education, 16*(5–6), 661–677.
McBride, R., & Knight, S. (1993). Identifying teacher behaviors during critical-thinking tasks. *The Clearing House, 66*(6), 374–378.

McCarthy-Tucker, S. N. (2000). Teaching style, philosophical orientation and the transmission of critical thinking skills in the US public schools. *Korean Journal of Thinking and Problem Solving, 10*(1), 69–77.

Michelli, N. M., Pines, R., & Oxman-Michelli, W. (1990). *Collaboration for critical thinking in teacher education: The Montclair State College Model (Series 3, No. 3)*. NJ: Institute for Critical Thinking.

Mitina, L. M., & Kuz'menkova, O. V. (1999). Psychological characteristics of intrapersonal contradictions in the teacher. *Russian Education and Society, 41*(4), 36–60.

O'Hara, L. A., & Sternberg, R. J. (2000–2001). It doesn't hurt to ask: Effects of instructions to be creative, practical, or analytical on essay-writing performance and their interaction with students' thinking style. *Creative Research Journal, 13*(2), 197–210.

Norris, S. P., & Ennis, R. H. (1989). *Evaluating critical thinking*. Pacific Grove, CA: Midwest Publications.

Paul, R., & Elder, L. (2001). *Critical thinking: Tools for taking charge of your learning and your life*. Upper Saddle River, NJ: Prentice Hall.

Rodriguez, Y. E., & Sjostrom, B. R. (1998). Critical reflection for professional development: A comparative study of nontraditional adult and traditional student teachers. *Journal of Teacher Education, 49*(3), 177–187.

Sato, M., Akita, K., & Iwakawa, N. (1993). Practical thinking styles of teachers: A comparative study of expert and novice thought processes and its implications for rethinking teacher education in Japan. *Peabody Journal of Education, 68*(4), 100–110.

Sears, A., & Parsons, J. (1991). Toward critical thinking as an ethic. *Theory and Research in Social Education, 19*, 45–68.

Shepard, R., Fasko, D., Jr., & Osborne, F. H. (1999). Intrapersonal intelligence: Affective factors in thinking. *Education, 119*(4), 633–642.

Snow, R. E. (1991). Aptitude-treatment interaction as a framework for research on individual differences in psychotherapy. *Journal of Consulting and Clinical Psychology, 59*(2), 205–216.

Sternberg, R. J. (1988). Mental self-government: A theory of intellectual styles and their development. *Human Development, 31*, 197–224.

Sternberg, R. J. (1994). Thinking styles and testing: Bridging the gap between ability and personality assessment. In R. J. Sternberg & P. Ruzgis (Eds.), *Intelligence and personality* (pp. 167–187). New York: Cambridge University Press.

Sternberg, R. J. (1997). *Thinking styles*. New York: Cambridge University Press.

Tillema, H. H. (2000). Belief change towards self-directed learning in student teachers: Immersion in practice or reflection on action. *Teaching and Teacher Education, 16*(5–6), 575–591.

Titone, C., Sherman, S., & Palmer, R. (1998). Cultivating student teachers' dispositions and ability to construct knowledge. *Action in Teacher Education, 19*(4), 76–87.

Udall, A. J., & Daniels, J. E. (1991). *Creating the thoughtful classroom*. Tucson, Arizona: Zephyr Press.

Wagner, R. K. (1997). Intelligence, training, and employment. *American Psychologist, 52*, 1059–1069.

Yeh, Y. C. (1997). *Teacher training for critical-thinking instruction via a computer simulation*. Unpublished doctoral dissertation, University of Virginia, VA.

Yeh, Y. C. (1999). A study of substitute teachers' professional knowledge, personal teaching efficacy, and teaching behavior in critical-thinking instruction. *Journal of Chengchi University, 78*, 55–84.

Yeh, Y. C. (2001). *The manual of Critical Thinking Test, Level II*. Taipei: Psychological Publishing.

Yeh, Y. C. (2004). Nurturing reflective teaching during critical-thinking instruction in a computer simulation program. *Computers and Education, 42*(2), 181–194.

Zhang, L. (2001). Approaches and thinking styles in teaching. *The Journal of Psychology, 135*(5), 547–561.

Zhang, L., & Sternberg, R. J. (2000). Are learning approaches and thinking styles related? A study in two Chinese populations. *The Journal of Psychology, 134*(5), 469–489.