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The Craft of Infusing Critical Thinking Skills: A Mixed-Method Research on Implementation and Student Outcome

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Despite the widespread recognition that educators, employers, and governing agencies view critical thinking (CT) as one of the most desired outcomes of higher education, research findings indicate that a majority of professors are not teaching it effectively. Employing a mixed methods explanatory sequential design, this study identified seven teaching strategies employed by faculty members to infuse preselected thinking skills into class content and their positive effect on students' higher order thinking abilities. The target population for the study was faculty members who participated in a CT development program to employ the infusion method to foster the thinking skills. Quantitatively, the study utilized extant data from the interviewed faculty members' respective students' CT application-focused recall-based pretest and posttests scores. Dependent t-tests were conducted, and the data were analyzed to examine whether students' (n = 133) scores were statistically and practically significant from the beginning to the end of the semester. Qualitative data were collected through semi-structured interviews with seven faculty members. Seven strategies for the infusion of the thinking skills emanated from a qualitative, systematic, thematic analysis of the interview transcripts: explicit teaching, intentional implementation, systematic practice, class discussions, teaching for transfer, modeling the skills, and fostering reflection. Data obtained through analyzing the extant pretest and posttest scores *revealed noteworthy advancement in the students' CT skills with significant effect sizes.*

Introduction

The importance and challenge of fostering critical thinking (CT) has captured the consideration of educators and continues to command the attention of scholars worldwide (e.g., Evens, Verburgh, & Elen, 2014; Gillespie & McBain, 2014). Despite the widespread recognition that educators, employers, and governing agencies view CT as one of the most desired outcomes of higher education (Hart, 2013), research findings (Crenshaw, Hale, & Harper, 2011) indicate that a majority of professors are not teaching CT effectively. In their seminal study, Paul, Elder, and Bartell (1997) surveyed 38 public and 28 private universities and results revealed that only 9% of surveyed faculty distinctly taught CT skills regularly in class. This incongruence continues to this day (Nelson & Crow, 2014). More recently, Abrami, Bernard, Borokhovski, Waddington, Wade, and Persons (2015) conducted a 2-stage meta-analysis on CT in higher education and concluded, "Despite a number of significant efforts to collate and review the results of previous empirical research on CT, the question of effective teaching strategies for CT remains outstanding" (p. 9).

My inquiry is founded on the assumption that CT skills can be taught and that Centers for Teaching and Learning (CTLs) can play a decisive role in the development of teaching practice aimed at enhancing students' higher order thinking. In 1987, Virginia Commonwealth University professor, James McMillan (1987) reviewed 27 studies and inquired on the effectiveness of instructional methods in college student's higher order thinking. He concluded that the results of the review did not "support the use of specific instructional or course conditions to enhance critical thinking" (p. 3). My study adds to the discussion, albeit with different results, as to whether specific instructions can foster CT in college students.

While most professors have honed their personal thinking skills, the majority do not possess the pedagogical background to foster them (Tsui, 2008), lack knowledge in balancing the teaching of CT skills with course content (Pascarella & Terenzini, 2005), and struggle with the amount of time required to plan appropriately (Tsui, 2001).

Although many empirical studies have examined CT in higher education, this mixed methods study responded to calls for effective teaching strategies that promote students' CT skills (Abrami et al., 2015). CT skills refer to abilities such as identifying parts of an argument, making inferences using reasoning, judging and evaluating evidence, recognizing fallacies, and solving problems, among other competencies (Paul & Elder, 2009). To determine the pedagogical effectiveness, I also investigated the results of CT instruction on students' CT skills gains via direct measures with a recall-based with short answers pretest and posttest design to measure students' initial understanding and application of the individual CT skills pre-selected by their professor and the changes, if any, after the intervention (one semester of these particular skills embedded into the course content). Five levels of knowledge were evaluated for each skill: definition, identification, application, metacognitive processes, and metacognitive knowledge.

Critical Thinking in Higher Education

An essential outcome of higher education is to develop students who think critically about academic subject matter and real-life problems (Tsui, 1999). As evidenced by substantial research (e.g., Abrami, Bernard, Borokhovski, Wade, Surkes, Tamim, & Zhang, 2008; Bloom, Engelhart, Furst, Hill, & Krathwohl, 1956; Dewey, 1933; Ennis, 1962; Facione, 1990; Glaser, 1941; McPeck, 1990; Paul & Elder, 2009), there has been a historical concern to systematically improve the quality of disciplined thinking and address its obstacles.

Analysis of existing literature suggests that most college students' exhibit inadequate CT achievement (Arum & Roksa, 2011; Pascarella & Terenzini, 2005). Some studies (e.g., Arum & Roksa, 2011) indicated more CT growth in the first two years of higher education, other (Tsui, 2008) registered that student CT development is greater in the final two years of college, and another disclosed that CT growth varies depending on different types of bachelor programs (Evens et al., 2014). Despite these incongruences, the commonalities among study findings are that CT can be taught (Lehmann, 1963) and that instruction enhances students' gains in CT while in college, albeit at modest levels (Arum & Roksa, 2011).

Instructional Methods for Critical Thinking

CT scholars consistently attempt to clarify the discourse on CT instruction by providing effective methods (e.g., class discussions and mentoring) and exemplifying instructional practices that contribute to its fostering (Abrami et al., 2015; Ennis, 1989). Tsui (2008) added to the discourse with her inquiry on CT and posited, "There is substantial evidence to suggest that critical thinking can be enhanced by purposeful instruction" (p. 201) but faculty need purposed training in the development of teaching practice aimed at enhancing CT (King, 1994).

Noted CT scholar and philosopher, Ennis (1989) categorized four instructional methods to teach CT: general, infusion, immersion, and mixed. The results from the 1-stage meta-analysis (Abrami et al., 2008) indicated that the infusion appeared as the next most effective method as evidenced by an effect size of .54.

Since the target population for this study was faculty members trained by our Center for Teaching and Learning Excellence (CTLE) in the infusion method, the focus of my inquiry was on this approach. The infusion method integrates the instruction of CT skills into the framework of class content in an explicit manner (Ennis, 1989) and embeds the CT skills in all curricular content so they permeate all aspects of a student's life (Dewey & Bento, 2009).

Method

This mixed methods study investigated which specific strategies faculty members employed to infuse pre-selected CT skills into their class content and examined if there was a significant difference in their students' performances of those CT skills as measured by the recall-based understanding and application-focused pretest and posttest scores.

Setting, Population, and Sample

I conducted the research at a private, liberal arts university in the midwestern United States with IRB approval. At the time of the study, the institution had an enrollment of 2,146 students. For the qualitative segment, the population of this study consisted of 17 faculty members who participated in a three-day workshop promoted by the CTLE. From 2009 to 2017, a minigrant provided stipends to professors who participate in "The Critical Thinking Project" (CTP). This project, funded and directed by the CTLE, included a three-day workshop and a semester-long infusion of specific CT skills the professors selected to embed in one of their courses. The workshop's purpose was to equip professors to teach CT via the infusion method (Ennis, 1989). The university's CTLE offered the workshop once during the

January interterm and twice in the summer. Each participating professor received 18 hours of direct and mentored instruction and a minimum of one semester of infusion of pre-selected CT skills in one of their courses. Participants had a student observer/researcher attend *each* of their classes during the semester to observe how effectively the professor was infusing CT into course content, to provide feedback to the professor and quantifiable information for the mentored instruction times. Edwards, Snyder, and Sanders (2016) described how these students researchers were trained, and clarified that

> the student researchers conducted several practice observations alongside an experienced member who modeled the process. Students also received supplemental instructional materials that described the process of recording observations and the definition of each item on the observation checklist. Mentors were readily available to answer questions and provided supervision of data entry and analysis during a member's first semester. (p.24)

A professor from each department was invited for an interview to attain a purposeful, maximum variation sampling. Of the eight departments, seven were represented. Both male and female professors were invited but only males responded and ages varied between 32 and 56. All of the faculty interviewed hold doctoral degrees with three being associate professors and four full professors.

For the quantitative analysis, the population comprised all the students (n = 133) who had taken classes with faculty members who completed the training and applied the infusion method. The faculty development model, implemented by the CTL, consists of a three-day workshop, individual consultations with the fellow for CT development, and daily class observations by trained student researchers. The students were 18-23 years old and ranged from freshman to senior, 40% males and 60% females, 95% Caucasian and with the remaining 5% being comprised of African Americans, Latinos, and Asian students.

Qualitative and Quantitative Data

The qualitative data were gathered through face-to-face faculty interviews utilizing semi-structured and open-ended questions. The interviews addressed faculty members' teaching strategies for the infusion of CT into their class content and were based on extant literature related to CT in higher education (Abrami et al., 2015; Andrews, 2000; Bouton, 2008; Ennis, 1989; Glaser, 1984; Reece, 2002). One question, in particular, focused on one of Ennis' (1989) fundamental aspects in the infusion process (i.e., teaching CT in an explicit manner). In addition to basing the interview questions on existing research, to check the interview questions for clarity and content validity, I conducted a pilot study with two faculty members, from the same target population, who had completed the training to infuse CT skills into class content (their answers were not used in this study). Finally, I asked two colleagues (one an expert in research design in CT, the other a professor whose specialty is in research writing and pedagogy) to serve as a review panel for the interview questions. The panel members stated that the instrument was suitable, the questions focused, and their sequence correct both for the issues being investigated and for helping faculty think through them. See Appendix A for the questions.

The extant quantitative data to which I had access was comprised of the sample students' CT skills pretests and posttests. The tests are recall-based with short answers requiring direct application of the thinking skills and were designed to measure students' initial understanding of the individual skills that were pre-selected and integrated by their professor throughout the semester. Professors normally select five specific CT skills presented in the workshop to infuse into their class content, and the project director developed pretests and posttests that contain the same structure but assess the specific skills (see sample of skills in Appendix B). As a result, each CT skill presented in the workshop has a corresponding CT test. The pretest and posttest are recall-based with short answers requiring direct application of the thinking skills and were designed to measure students' initial understanding of the individual skills that were pre-selected and integrated by their professor throughout the semester. For example, if one of the skills chosen is detecting "underlying assumptions," students take a pretest and posttest for that particular skill. The students take the pretest during the first week of class and the posttest in the final week of class. Five levels of knowledge were assessed for each skill: definition of the CT skill (2 points), identification of transfer (3 points), application (points vary from test to test ranging from 8 to 12 points), and metacognitive process (9 points). Scores for each CT skill test range from 22 to 26 points. The Fellow of the university's CTLE, who also directs the CT faculty development, trained the student researchers not only to observe the infusion of CT into course content, but also to score the pretests and posttests following a rubric and with direct supervision so faculty members did not grade them, thus preserving inter-rater reliability. Each professor is assigned one student researcher for the entire semester. A total of seven student researchers are represented in this inquiry.

The pretest and posttest assessments were based on CT scholar Beyer's (1985) three-step process and his focus on transferability of the skills. Beyer termed the three-step (3D) process "defining, doing, and discussing." Beyer purported that (1) defining the CT skill helps develop a mental framework appropriate for executing the skill; (2) doing involves appropriately executing the skill by solving a given situation; and (3) discussing the steps encompasses explaining students' train of thought to address the issues and questions presented. In addition to the above three steps, the instrument also includes an additional component that Beyer considered crucial for teaching CT, the ability to transfer the CT skills to another domain. Students are asked to answer the following question, "When could you transfer this skill into your personal life? Give specific examples." The director developed the assessments to incorporate Beyer's four steps noted above. Beyer's (1985) theoretical framework provided content validity for the CT skills tests. Reliability analysis revealed a strong Cronbach's alpha coefficient (α=.82).

Data Analysis

First, two-tailed dependent *t*-tests of the pretest and posttest scores were conducted, and the data were analyzed to examine whether students' scores were statistically ($p < .05$) and practically (Cohen's *d*) significant. Second, the interview generated a list of interventions used by faculty to infuse CT into their class content. I compared the findings with the professors' respective students' scores with students' CT gains associated with those interventions. After I transcribed the interviews, data analysis proceeded through repeated and systematic review of all interview transcripts. This inductive process identified categories and themes from the raw data. I employed a limited summative content analysis by counting words related to the themes. The goal was to explore the usage of repeated keywords in an inductive manner whereby patterns and themes emerged.

Findings, Exemplars, and Implications from the Qualitative Data

Seven professors from distinct departments described the strategies they used to embed their selected CT skills into their course content. The line-by-line analysis and the summative content analysis related to the themes, revealed seven recurrent and specific strategies: making the CT skills explicit, being intentional, providing systematic practice, promoting class discussions, modeling the skills, fostering the transfer of the skills, and employing assignments that required reflection.

Figure 1. Evidenced-based pedagogical strategies for infusion of CT.

Make the CT skills explicit in class content
- Recognize which CT skills are already part of course content
- Explicity by isolating, defining, and outlining the steps employed to achieve them

Be intentional about teaching the CT skills
- Take purposeful time during the summer to embed the thinking skills into lectures, revamp old assignments, assessment and class activities

Repeatedly practice the CT skills in class
- In CT, "there is no surrogate for repetitive practice" (Mulnix, 2010)

Promote class discussions
- Whole class or small group discussions are especially effective in teaching higher order thinking skills.

Model how to implement the CT skills
- Instructor models not only the inclicnation to think critically, but the steps in how to achieve it in the classroom.

Facilitate purposed transfer of the skill to other contexts
- Connect the CT skills to another setting is indispensable for students to master them effectively.

Design assignments requiring students' reflection on the CT skills
- The professors indicated that reflective assignments afforded students the opportunity to expand their personal grasp and knowledge of the thinking skills.

Notably, a few of the strategies incorporate multiple approaches. For example, one teaching strategy may fit into the class discussion strategy while concomitantly being explicit and reflective. In the interest of constancy, I assigned those "multiple-strategies" to the category explicitly mentioned.

Explicit Teaching

All seven professors (100%) posited that their first strategy was to make the CT skills perceptibly explicit to the students. The professors had various approaches in how to make them explicit. In addition to including their pre-selected CT skills into the syllabus, some added them to the course calendar specifying which skill (e.g., developing an argument or investigating underlying assumptions) was being utilized in each assignment and reading, thereby making the appropriate CT skills clearly forefront.

All professors utilized handouts provided by the CTLE, which included the definitions of the CT skills and the required steps to execute them. Most integrated the CT skills prominently into the lecture while two had students announce (call out) when they recognized them in the lecture or group activities. Others asked students at the end of each class which of the CT skills had been embedded that day.

Findings confirmed the consensus in the literature indicating that when instructors teach CT explicitly, students become more proficient thinkers (Halpern, 1999). Correspondingly, proponents of explicit instruction argued that CT skills are not likely to develop if the teaching occurs in a covert manner (Elder & Paul, 2010; Friedel, Irani, Rudd, Gallo, Eckhardt, & Ricketts, 2008).

Intentionality

All seven professors (100%) purported being deliberate and purposeful in infusing the CT skills not only into class content but also in each lesson (i.e., lecture, assignments, assessments, and discussions). When they were asked, “What were the teaching strategies you employed to infuse the selected CT skills in your content?” many began by stating, for example, “Well, I had to be very intentional about it.” They revealed that without this intentionality, they would not have been particularly effective in the infusion of their selected skills. Being intentional was a specific focus of the training they received.

A common theme was allocating purposeful time during the summer to embed the CT skills into their lectures, updating old assignments, assessments, class activities, syllabi, and even adjusting their vocabulary to reflect the CT skills. One professor provided an example of how he embedded his selected CT skill of *identifying logical* fallacies: “I created an entire lecture to focus on one of the skills. When we were talking about how to make smart financial decisions for corporations, I put together a bunch of logical fallacies. I've got video clips in there, and it is more interactive than a lecture."

This study reinforced the findings of previous research (Phelan, 2012), which demonstrated that when CT "is implemented intentionally, it can result in positive gains in students' critical thinking" (p. 163). This intentionality requires more than making the skills explicit; it involves a deliberate effort in implementing the needed adaptations and should be reflected in every aspect of the course, including learning objectives, in addition to the ones previously mentioned.

Systematic Practicing

A repeated theme that emerged from the interviews was the recognition, by 100% of the professors, that systematic and repeated practice is essential for mastering the CT skills. Some practiced the skills abundantly with problem-solving situations; others embedded the skills in the reading assignments.

One professor, whose "diagramming" was one of his selected skills, indicated asking the students to draw a diagram of the lecture at the end of each class while another involved his students in practical research to immerse them in the CT skills. Another professor requested students to write minute-papers (i.e., one cogent paragraph) at the end of each class distinctly connecting one of the CT skills to the material covered in class. Systematic practice implies applying the thinking skills in class immediately after learning them, which is congruent to Beyer's (1985) claim that upon teaching the thinking skills, deliberate and immediate application must follow.

Class Discussions

The fourth instructional strategy was class discussion. Six (85%) of the participants described small-group or whole-class discussions as a key strategy to infuse the CT skills. This strategy was prevalent as professors posited that the discussions rendered opportunities for students to think critically about the class content while practicing the CT skills.

The professors engaged students with the CT skills discussions in a myriad of ways: by having students explore controversial topics, by assigning groups to seek alternate views to the ones presented in class, by asking students to detect underlying assumptions, and subsequently, by sharing the distinct outcomes with the entire class. Other strategies mentioned included students individually working through concept maps or decision trees and then in small groups producing one cogent paragraph on the topic indicating which of the CT skills they employed. Dominant strategies included think/pair/share or write/pair/share that encouraged students to problem solve individually and in groups. One professor purported, "lectures are outmoded" and advocated that classes should be comprised mostly of small-group discussions with the integration of the CT skills.

This preferred strategy is congruent with Abrami et al.'s (2015) results in their meta-analysis on CT. Their investigation revealed that discussion seems to be especially effective in teaching higher-order thinking whether professors utilized whole-class or small-group discussions.

Modeling the Skills

Modeling the skills was the fifth most repeated strategy**.** Six professors (85%) disclosed modeling the thinking skills in their classrooms. They reasoned that, as students observed them engaging in the process required to implement the skills, the observation would instigate the students to engage in it more successfully.

Three professors expounded the merits of consistently modeling good questions thereby creating a context for quality thinking (e.g., they selected question stems such as, explain why…? Explain how…? What is the main idea of…? What conclusions can you draw from…?). Yet another professor purported modeling metacognitive questions (e.g., How would you think about…? What thinking process did you employ to decide …?). This strategy corroborates several CT scholars' previous research (e.g., Carlson, 2013; Elder & Paul, 2010; Halpern, 1999, Smith, 1977) that support modeling as an effective method to foster CT.

Teaching for Transer

Teaching for transfer was the sixth strategy. The ability to apply the CT skill effectively in another setting emerged as another central theme among six of (85%) the professors' narratives. They agreed that purposefully connecting the CT skills to another setting is indispensable for CT skill mastery. One professor did not focus on transfer; nevertheless, he still acknowledged its value.

A few professors invited guest speakers from different academic disciplines to relate how the CT skills applied to their particular field. Others explicitly delineated how these skills transferred to diverse settings and were relevant to personal life decisions, sports, and family life. Since the extant literature has revealed that higher education students do not naturally transfer CT skills learned in the classroom to real-world context (Paul & Elder, 2009), teaching them to apply the thinking skills to personal matters, other disciplines, and community issues is critical. This finding reinforces a growing body of scholarly work (e.g., Ennis, 1989; Halpern, 1999; Tsui, 2008) that supports transfer as a recognized method that leads to greater CT outcome.

Reflective Assignments

The seventh strategy most frequently mentioned was reflective assignments. Six (85%) professors selected reflective assignments as a strategy to infuse CT skills into class content. A few professors stated that reflective thinking and writing promoted intellectual growth, thus enhancing students' CT abilities.

Exemplars of reflective assignments included assigning journal logs and reflection questions. Students were asked to reflect on an essay and to check their underlying assumptions or stereotypical tendencies. Other reflective assignments endeavored to keep students from compartmentalizing their learning while attempting to help them consider issues through others' perspectives. The professors indicated that reflective thinking and writing afforded students the opportunity to expand their personal grasp of the thinking skills and promoted intellectual growth, leading to the enhancement of students' CT abilities. Their statements mirror John Dewey's (1910) affirmation of the connection of reflective thinking and higher order thinking.

Results from the Quantitative Data

In addition, exploring effective pedagogies, I wanted to investigate their effectiveness (and possibly the effectiveness of the CTLE training) as evidenced by whether there were significant difference between students' pretest (prior to CT infusion) and posttest (post-CT infusion) scores. Extant quantitative data of the faculty members' respective students were investigated to discern if there were gains in the students' CT skills from the beginning to the end of the semester. Both descriptive and inferential statistics (dependent t-tests) were used to analyze the data. The results from the dependent t-tests conducted demonstrated gains for all students in every skill and results revealed growth in 88% of the individual skills to be both statistically ($p < .05$) and practically significant with medium ($d > .5$) to large effect sizes ($d > .8$) to very large ($d > 1.30$). The practical significance was either large or very large in 73% of the skills, medium for 15%, and small for 12%. The Cohen's effect sizes in this study establish high practical application that is relevant for educational decisions regarding the infusion of CT skills and its positive effect on the students (see Tables 1 and 2 for example).

Table 1

Descriptive and t-stats for CT Skills Pretest and Posttest, (N=16)

	Posttest		Pretest		*t*	*p*	*Cohen's d*
CT Skills	*M*	*SD*	*M*	*SD*			
Analyzing Assumptions	.7216	.2655	.5163	.2606	3.200	.006	.780
Developing an Argument.	.7270	.2709	.6050	.2824	1.495	.156	.4409
Defining the Problem.	.7834	.1957	.6025	.2481	2.758	.015	.7984
Asking Good Questions	.8506	.1505	.6356	.2684	3.011	.009	.9881
Unequal Weights	.5378	.4400	.2400	.4298	2.940	.010	.6847
Multiple Perspectives	.7682	.1919	.5394	.3093	3.047	.008	.8889
Hypothesis Testing	.5250	.3122	.4166	.4245	1.268	.224	.2909
Total	.7019	.2610	.5079	.3176	2.531	.061	.6960

Table 2

Descriptive and t-stats for CT Skills Pretest and Posttest, (N=14)

	Posttest		Pretest		*t*	*p*	*Cohen's d*	*r*
CT Skills	*M*	*SD*	*M*	*SD*				
Analyzing Assumptions	.5093	.1307	.4415	.2123	1.374	.205	.384	.181
Asking Good Questions	.5974	.1382	.4771	.1977	2.710	.018	.7005	.331
Compare and Contrast	.5963	.1311	.4448	.1870	4.442	.001	.938	.425
Unequal Weights, Equal Measures	.2539	.2914	.1657	.2541	1.680	.117	.322	.159
Multiple Perspectives	.5899	.1629	.4351	.2615	3.480	.004	7106	.335
Total	.5094	.1709	.3928	.2225	2.737	.069	.6110	.286

Results and Implications from the Quantitative Data

As evidenced by the results from the two-tailed dependent *t*-tests conducted, 100% of the students' individual skills scores increased from pretest to posttest. In addition, results show growth in 88% of the individual skills to be both statistically ($p < .05$) and practically significant with medium ($d >$ .5) to large effect sizes ($d > .8$). The results in this study indicate that CT skills are not only measurable but also can improve meaningfully through the course of one semester when a combination of effective CT teaching strategies are infused into course content.

In her research on cultivating CT in higher education, Tsui (2008) highlighted the fact that very little is actually known about how to develop CT skills in students, and in Phelan's (2012) more recent CT research on enhancing student CT thinking knowledge, skills, and dispositions, he underscored Tsui's assertion emphasizing, "limited evidence exists to verify its [CT] successful attainment" (p. 10). The results from this current study added to the discourse on these outstanding issues by providing insight into the development of the CT skills and evidence suggesting that instructional interventions can have decisive and positive impact on the students. The results also add to the dialogue on the effectiveness of the infusion method (Ennis, 1989) to enhance student's higher order thinking skills and the efficacy of specific faculty training on how to teach CT.

Implications for Teachers and Faculty Developers

When it comes to teaching CT, studies consistently reveal that institutions of higher education affirm CT as a widespread objective but faculty members have difficulties demonstrating how they foster (Abrami et al., 2008; Paul et al., 1997) and teach CT (Nelson & Crow, 2014). Tsui (2001) conducted a qualitative case study in which she interviewed five faculty members, five college students, and one administrator at each of the case study sites (four universities). Her findings suggested that faculty benefit from sharing teaching successes with colleagues who are dealing with similar scenarios. The findings and results from this study aid in the dissemination of the infusion method and effective teaching strategies, facilitated by the CTLE training and by sharing how seven faculty members have successfully fostered the enhancement of their students' CT abilities.

This inquiry has five primary implications for teachers and faculty developers. First, educators who desire to underscore CT but do not have a "road map" may benefit from understanding the pedagogical process undertaken by fellow colleagues. Teachers and faculty development programs may optimize their effectiveness in the training and infusing CT skills by adopting all or some of the seven effective strategies that emerged from the interviews. These strategies not only are supported by the extant CT literature, but also contributed to substantial gains in students' CT skills.

Second, research indicates that many faculty members view teaching CT skills as time consuming (Wang & Wang, 2011), difficult to plan (Tsui, 2001), and at times, the infusion process hinders content coverage (Friedel et al., 2008). Contrary to these concerns, after the CTLE training, several professors stated that they did not feel that teaching CT skills took a toll on class content as they were able to, with intentionality, seamlessly infuse them into their courses. Several professors even noted that some of their selected skills were already part of their class content but had not been obvious to them or their students. By taking the time to recognize which higher-order thinking skills are already part of their course content, and explicitly infusing them into their class, educators can have a significant impact in student's thinking growth. With this in mind, educators and CTLs may benefit from recognizing that a simple, yet critical initial step in teaching students to think critically is to help faculty identify which CT skills they already implicitly teach and subsequently make them explicit. According to the faculty members interviewed, making the skills explicit neither required an inordinate amount of time nor affected class content. These findings support Phelan's (2012) research conclusion in which he stated, "Findings from the current study suggest that aspects of critical thinking can be enhanced without entirely revamping a course or developing a course focused solely on critical thinking" (p. 155). These steps are not meant to convey that imparting proficient thinking in college students is a simple process. On the contrary, I concur with Abrami et al.'s (2015) statement, "The teaching of CT is a complex and multifaceted process in which there is no magic recipe" (p. 24). Rather, the implications are that strategic steps can be conveniently and competently facilitated by the CTL in order to prepare their faculty to embed the thinking skills.

A third implication for both faculty developers and for other educators who have a desire to promote CT abilities involves intentionality both in training and application. A critical step in the infusion of specific CT skills encompasses the deliberate embedding of the CT skills into lectures, assignments, assessments, and class discussions. The following steps emerged from the interviews: 1) Designate a few hours during the summer to select a few familiar CT skills and fit well with course content; 2) Prepare a packet with selected CT skills, provide definitions, and outline the steps required to achieve them; 3) Deliberately embed the selected skills in the syllabus, course calendar, and power point presentations. When professors were trained to follow these steps, the infusion method lasted throughout the semester. Faculty developers and other educators may be encouraged to realize that with a few hours of preparation can substantially increase effectiveness in imparting CT skills. Abrami et al. (2008) construed, "The infusion of CT requires deep, thoughtful, and well understood subject matter instruction" (p. 1106). The steps revealed provide effective tools to incorporate CT skills into course content.

Considering that faculty development plays a vital role in students' CT outcome (King, 1994), the fifth implication is for those who recognize that students' success in thinking critically rests considerably on faculty's ability to effectively foster it and the training they receive to achieve it. Institutions of higher education through can utilize their CTLto promote effective CT pedagogy to prompt this outcome. Phelan (2012) addressed the paradox of the apparent insufficient training and support of faculty "to integrate effective critical thinking strategies into their teaching practice, particularly if the institution really desires to achieve this oft-cited learning outcome" (p. 8). The findings and results of this study provide empirical evidence that faculty training in effective pedagogy for teaching CT not only heightened professors' ability to infuse CT skills, it also served as a catalyst that promoted documented, measurable, and significant student growth in skillful thinking, a highly prized student outcome. Prior studies have stressed this same recommendation (Elder & Paul, 2010), and they mirrored educational psychologist King's (1994) admonition, "Most university professors do not know how to teach critical thinking because they have never been provided with pedagogical methods for doing so" (p. 17). Institutions of higher education must spearhead faculty development to foster a CT ethos and incentivize their educators by providing well-organized training, and a forum for faculty to discuss pedagogical trends in CT.

Conclusion

By conducting a mixed-methods study, I investigated pedagogical strategies employed by seven faculty members to infuse CT skills into course content throughout a semester as well as tested their effectiveness as evidenced by pretest and posttest scores. The data exhibited both statistical and practical significance giving evidence that these broad pedagogical strategies were successful in fostering students' CT skills. Another fundamental contribution of this work is not only the validation that embedding specific CT skills into course content is an effective manner to foster students' CT but also the fact that the pedagogical strategies revealed in this study can support faculty members who are seeking to make their courses more CT based. By elaborating on the seven effective strategies used to embed CT into class content, faculty developers would profit from investing in focused faculty CT instructional methods. CTLs, in particular, could provide a method for faculty development that includes training in the infusion method (Edwards, Snyder, & Sanders, 2016) which could effectively enhance their students' higher-order thinking

As in any study, this one includes a few limitations. First, there was no counterfactual condition against which the treatment was compared. Second, taking a pretest may affect the score of a posttest. Pretest-posttest designs are widely used in research, predominantly for comparing the intervention results. Sixteen-weeks separated the pretest from the posttest, which may partly mitigate the threat (Creswell, 2012). Third, the maturation effect can affect pretest-posttest designs. In this inquiry, the students were approximately the same age and 98% of them lived on-campus, sharing many similar experiences. Creswell posited that for research purposes, "selection of participants who mature or develop in a similar way" (p. 304) helps mitigate the maturation threat. Regardless, there might be alternative or unidentified cognitive factors that impacted the results. Future studies could use random sampling technique.

Generalization was not a goal in this study since neither the faculty nor the student sample was random. For the qualitative aspect of this mixed methods research to be transferrable, I attempted to present detailed-rich information and specific methodology in hopes to allow the readers to conclude whether the findings are transferrable to their situations.

This study purposefully focused on investigating effective strategies for the infusion of CT skills. During the interviews, several of the professors also mentioned focusing on students' thinking dispositions. The thinking skills relate to the ability to analyze arguments, make inferences, evaluate sources, and solve problems (Facione, 1990) among other abilities, while CT dispositions embody consistent attitudes, intentions, intellectual virtues, and tendencies that reflect habits of mind (Ennis, 1996). Research has demonstrated that CT embeds both CT abilities and dispositions (Ennis, 1987); Facione, 1990; Halpern, 1999; Stanovich & West, 1997). After his 2012 research on CT, Phelan remarked, "While the literature has suggested that increases in critical thinking skills and dispositions go hand in hand, research in this area is still in its infancy" (p. 148). As a result, a recommendation is to expand this current research by investigating the pedagogical process to foster the dispositions.

The faculty sample was composed of all males. Results from the Faculty Survey of Student Engagement (Laird, Garver, & Niskodé, 2007) indicated, "that women faculty members emphasized higher order thinking skills, active and collaborative learning, and diversity experiences" (p. 2) differently than their male counterparts. Considering the survey's findings and the fact that this current research sample was not able to include female faculty members, I recommend including female faculty members in future studies as their input may provide distinctive strategies.

Finally, the present investigation did not isolate the effects of each individual strategy; therefore, no specific strategy can be itemized as essential or unessential in the instruction of CT skills. Future research could itemize individual strategies.

Summary

In summary, this mixed-methods study identified teaching strategies professors employed to infuse CT skills into class content. In addition, it also inquired about the effect the strategies had on students CT abilities.

Seven strategies for the infusion of CT emanated from the qualitative data analysis from the interviews: explicit teaching, intentional implementation, systematic practice, class discussions, teaching for transfer, modeling the skills, and fostering reflection. Data obtained from extant quantitative data (pretest and posttest scores) of the faculty members' respective students (n = 133) revealed significant statistical and practical improvement in the students' CT skills. The insights derived from this mixed methods study provides a better understanding of the strategies, process, and effectiveness of the infusion method that help support faculty development and students' CT skills development.

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Appendix A
Interview Question Pool

Question Pool and Supporting Research

Number	Question
1	What are the teaching strategies you employed to infuse the selected CT skills in your content? a. How did you infuse CT skills into class lectures? b. How did you infuse CT skills into class activities? c. How did you infuse CT into class assignments? d. How did you infuse CT into class assessments?
2	In your opinion, what were your most effective teaching strategies to infuse CT skills into your content?
3	Some CT teaching strategies are implicit; some are explicit. How did you teach your selected CT skills explicitly?
4	What were the teaching strategies you employed to help students transfer CT skills to another domain (such as other disciplines or settings)?

Appendix B
Sample of CT Skills Selected by the Faculty Sample

Compiled by Stephen Snyder, PhD

Analogical Reasoning: It is reasoning that sees the similarities among essentially different objects or ideas and using existing knowledge about the first set of objects or ideas to understand the others.

Analysis: It is a method that takes apart (disassembling, deconstructing) an event, issue, or media presentation in order to perceive or establish patterns or relationships.

Analyzing An Argument: Finding a sound argument:

- premises are acceptable and consistent
- premises are relevant to the conclusion and provide sufficient support for the conclusion
- missing components have been considered and are judged to be consistent

Analyzing Assumptions: It is evaluating assumptions which are statements made in support of an argument for which no proof or evidence is offered. Therefore, one must evaluate these statements to determine if there is really evidence to support the statement.

Compensatory Unequal Weights Decision Making Model: this strategy is used to make wise decisions by evaluating the possible options and selecting the best one for the given situation.

***Decision Making*:** used to make wise decisions by evaluating the possible options and selecting the best one for the given situation.

Developing an Argument: It is the ability to form a logical stance with identified assumptions, premises, facts, opinions, conclusion, and counter-argument.

Diagramming a visual representation of a problem, presenting all of the relevant information and providing a necessary solution path to the goal in an easily understood way.

Hypothesis Testing: It is one way to find out about the way the world works. The goal of hypothesis testing is to make accurate predictions about the portion of the world we are dealing with.

IDEAL Model : It is the process of overcoming a difficulty by applying the right strategies to arrive at a quality solution (Identify, Describe, Explore, Action, Look back and evaluate)

Logical Fallacy: It means to spot ideas or assertions founded on erroneous logic or perception.

Multiple Perspectives: It is a way of thinking which enables the learner to see from many different points of view.

Operational Definitions: It is the skill of defining terms that you will use in a written or oral conversation, diagnosis, or research question for a given situation for clarity. An operational definition specifically defines a variable or phenomenon for a given task or situation

***Probability*:** thinking about the probability of an event taking place in order to solve a problem or make a decision.

***Problem Solving*:** the process of resolving an obstacle or difficulty by applying the right problem-solving strategies at the right time to arrive at a quality reflective solution.

Searching for a Pattern: A method for organizing a complex set of attributes or elements so a problem may be solved systematically

***Similar Problems*:** a method for analyzing the core of a complex problem before considering specific aspects of it by looking at a simpler, but similar problem.

Synthesis Putting together ideas and knowledge in a new and unique form; grouping and organizing information to make a whole.