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Faculty Development for Fostering Students' Critical Thinking

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Given the complexity of fostering critical thinking (CT) skills in undergraduate students and the lack of effective faculty training methods, the authors provide a comprehensive and evidence-based framework to prepare faculty in the instruction of CT skills. The model consists of an extensive workshop, mentoring, daily classroom observations, informative feedback consultations, and an end-of-semester feedback report on students' higher order thinking growth. Two aspects of the training were assessed: Did consultations impact professor's pedagogy in fostering CT? Did professors' level of experience with this model impact students' CT gains? Fifteen professors were assessed during seven semesters (45 classes and 904 students). Results indicate that between first and second consultations, professors demonstrated statistically significant change ($p < .05$) in the frequency of four of the six pedagogical processes. Professors' training experience in this model significantly affected student growth ($p < .01$) within three levels of CT knowledge. Findings reflect the benefits of a program model that offers continued feedback and training to professors.

Introduction

Improving students' critical thinking (CT) is a vital aspect of undergraduate instruction, as scholars in both private and public sectors have observed (Hart Research Associates, 2013). Although a conglomeration of variables influence students' thinking, including non-academic experiences (Terenzini, Springer, Pascarella & Nora, 1995), students' success in thinking critically rests considerably on faculty members' ability to effectively foster it (Tsui, 2008). Though pedagogy is crucial for student development, most faculty are not hired for—nor do they have training in—effective methods of nurturing higher order thinking. Over 20 years ago, educational psychologist King (1994) concluded that it was unreasonable to expect professors to instinctively and effectively teach CT without purposed faculty training. Not much has changed since. Phelan (2012), in his CT research, underscored, "it remains a paradox that so little effort is directed toward training and supporting instructors 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). Faculty development plays a vital role in students' CT outcome, making a compelling case for programs that capacitate faculty to develop effective pedagogy for the enhancement of students' thinking skills.

Even though faculty development and effective pedagogy play a vital role in CT development (King, 1994), a review of the literature reveals limited models designed to help faculty infuse CT skills into class content. The models identified included workshops, seminars, classroom observations, reflective journals, portfolios (Amundsen & Wilson, 2012), or offered instructors pre-packaged materials, which did not address the complexities of student CT development and its pedagogical framework (Paul & Binker, 1989). Altany (2011), who directs a center for faculty and learning, added to the discussion in his reflective essay on professional faculty development, suggesting, "the traditional workshop model of faculty development seldom results in fundamental changes" (p. 84). Most recently, Amundsen and Wilson (2012), in their literature review on faculty development, posited that educational development in higher education is still an emerging field of study and the review revealed a need for a more "detailed description of practice" (p. 91). We are adding to the discussion based on our experiences employing a robust, evidence-based training model to foster students' CT growth.

Our Focus

What are proven methods to train faculty on effective ways to foster CT in their students? Are workshops effective? How long does faculty training have to last? Should this type of training be mandated? How do we know if faculty members are implementing what they learned? How can educators be best empowered to promote CT? We begin by providing a comprehensive framework for faculty development in the infusion of the CT skills and dispositions that has been in use for seven years and has significantly improved students' higher order thinking skills (Snyder, Edwards, & Sanders, in press). Besides providing the framework, we decided to measure two aspects of the training: 1) the influence of consultation feedback on professors' pedagogy and 2) the effects of faculty level of experience within the model on student CT gains. We agreed with Bélanger, Bélisle, and Bernatchez (2011), who assessed the impact of their own educational activities, and stated, "It is noteworthy that only very few centres have examined the impact of their activities in teachers' practices" (p. 133).

We use the term CT skills to refer to specific abilities (see Appendix A for examples) such as identifying parts of an argument, making inferences using reasoning, judging and evaluating evidence, recognizing fallacies, and solving problems, among others (Ennis, 1991). CT dispositions relate to an inclination to think critically (Ennis, 1991). Finally, since there are multiple definitions of CT itself, we adopted philosopher and CT scholar Ennis's (1991) definition: CT is a "reasonable, reflective thinking that is focused on deciding what to believe or do" (p. 6).

First Part:
The Pedagogy and the Model

Since 2009, our university's Center for Teaching and Learning Excellence provides a mini-grant to professors who volunteer to participate in "The Critical Thinking Project" (CTP). Although there are multiple ways to foster CT, the model followed the infusion method. Ennis (1987) investigated four frameworks that fostered students' higher order thinking: general, infusion, immersion, and mixed. Our CTP director (second author) chose to focus the faculty development on the infusion method, which embeds the instruction of CT skills into class curriculum explicitly as CT empirical investigation increasingly validates its effectiveness (Abrami et al., 2008).

The CTP has had longevity, cost effectiveness, and efficiency over a period of nine years due to the Bedi Center of Teaching and Learning Excellence (BCTLE) director, faculty partnership and quality undergraduate student observers and researchers. The endowment of the BCTLE has funded the project so a small stipend to professors is provided; the faculty director of the program receives a three-credit overload each semester and in the summer.

Seven Distinct Pedagogical Practices

The model equips faculty in the use of seven distinct pedagogical practices related to CT that have been found to significantly affect student gains in CT (Snyder et al., in press). As noted in *Figure 1*, these practices include infusing CT skills explicitly and implicitly, initiating critical dialogue, providing guided modeling and practice, teaching for transfer, emphasizing metacognition, evaluating student progress, and incorporating dispositional instruction.

Figure 1

Evidenced based pedagogical practices for the fostering of CT

1. Infusing CT skills explictly and implictly
    - Explicity by isolating, defining, and outlining the steps employed to achieve them (Halpern, 1999)
    - Implicitly is the mention of a skill without the stipulation of specific step (Beyer, 1988)
2. Initiating critical dialogue
    - Oral and written discussions in which students are solving a problem or issue (Abrami et al., 2015)
3. Providing guided modeling and practice
    - Instructors model the application of the skill to a content-specific problem (Abrami et al., 2015
    - Students are given opportunity to practice applying the skill with assistance from peers or the instructor
4. Teaching for transfer
    - Instructors prompt students to consider parallel situations where the same skill may be applicable (Phelan, 2012)
5. Emphasizing metacognition
    - Students are taught to recognize when to employ the skills and the monitoring of cognitive processes (Snyder et al., 2016, under contract)
6. Evaluating progress
    - Students are evaluated via quizzes, tests, discussions
7. Incorporating dispositional instruction
    - Course is structured to encourage students'onsistent attitudes and tendencies that reflect habits of mind (Facione, 1990)

During the training process, faculty learn the benefit of first teaching the CT skills explicitly by delineating the specific steps used to apply them. Instructors then initiate critical dialogue through the use of active learning strategies as they model the application of the skill to a content-specific problem and encourage students to consider parallel situations where the same skill may be applicable. This transfer instruction allows students to effectively solve new problems in unfamiliar contexts using their existing skill set (Beyer, 1988). As students practice applying the skills, professors prompt them to examine their own metacognitive processes to plan, monitor, and assess the appropriateness of their chosen CT strategy. The professor subsequently evaluates the students through quizzes, tests, and discussion, which enables students to assess their own progress in mastering the skills. Lastly, professors also focus on developing within their students the general dispositions, such as truth seeking and open mindedness, needed to engage in critical thought. It should be noted that the use of these practices does not necessarily progress linearly but rather should be viewed as a fluid process where elements often overlap. When all seven practices are utilized, students develop a complete understanding of what, when, how, and why they should apply specific CT skills (Snyder et al., in press).

A Robust Model

This faculty development model encompasses:

- a three-day workshop,
- the development of a CT-embedding portfolio,
- direct mentoring with the project director,
- class observations throughout the semester,
- four consultations with the program director and class observer throughout the semester,
- an end-of-semester cumulative report on student growth,
- at least one semester-long infusion of specific CT skills into a selected class.

Workshop

Each summer and January interterm, the Center for Teaching and Learning Excellence hosts a three-day workshop during which volunteer faculty learn strategies for infusing their pre-selected CT skills into class content and assessments. The number of new participants ranges from two to six professors each year, and every professor in the program receives 18 hours of direct and mentored instruction.

- Day 1: Each participant receives a 3-ring binder with all of the material needed for the infusion framework. The first day training focuses on an overview of CT, the infusion model, and guided practice in CT. Professors begin initial work on their CT teaching portfolios by selecting five CT skills to infuse in their course.
- Day 2: Time is spent on more direct instruction with intentional collaborative discussion. The CT dispositions are presented and special focus is given to the metacognitive processes. Faculty begin to fill out a matrix on the sequence of the dispositions, which will be included in the portfolio.
- Day 3: The last day continues with direct instruction and collaborative discussion. The focus is to equip faculty in how to foster transfer of the CT skills, assessment, and selection of evaluation procedures.

Mentored Instruction

Included in each of the workshop days is individual time with the CTP director. Mentoring professors on how to effectively integrate the thinking skills into their class is optimal (Abrami, 2015). The individually mentored instruction takes place in the days of the workshop and lasts for approximately one hour. The professor sets up an appointment with the CTP director to ask specific questions and continue to focus on applications to a specific course. The mentored instruction is an important step as the faculty members leave the workshop with a solid framework from which to develop their portfolio. The CTP director is also available throughout the summer to meet with individual professors and answer questions as needed.

Portfolio Development

Professors who participate in the program create portfolios disclosing which CT skills they selected to infuse into their course content. In the portfolio, faculty members include how and when in the semester they will infuse both the CT skills and dispositions and the manner in which they will assess their students CT development. The portfolio comprises of four matrices completed by the participating professor and containing the following information: 1.) Selection and sequence of CT skills; 2.) Selection of CT dispostions; 3.) Assessment plan for CT skills; and 4.) Methods used for the CT skills instruction. See *Figure 2* for an example of implementation of selection and methods:

Figure 2

Sample of Selecting, Sequencing, and Methods of Instruction for a Child and Adolescent Psychology Class

Selecting and Sequencing CT Skills

Select Five Thinking Skills to Teach	**Locate in Syllabus where to Introduce the Thinking Skills Explicitly**	**Indicate the Content Areas Where Students Will Practice Thinking Skill**
1. Multiple Perspectives	Nature of Children's Development Chapter 1, Session 2	Nature of Children's Development Dev't Theories
2. Detecting Stereotypes	Birth – Chapter 4 2nd session	Moral Dev't Educational Issues, Disabilities, Gender Issues

Determine the method of instruction that will be used in each of the areas below

Skill Area	**Introduction of Skill**	**Guided Practice**	**Transference of Skill to other content areas**
1. Multiple Perspectives	Lecture Kaczynski & Walker Discussion	Scenario Analysis Elective C-Section Discussion	Scenario Analysis "Assessing Local Needs" Activity
2. Detecting Stereotypes	Lecture with discussion group: "Country of Cognito"	Scenario Analysis: · "Going Back" · Elective C-Section Discussion	Scenario Analysis: · Cochlear Implant Group Discussion

The faculty members submit the portfolio to the program director within three weeks of the end of the workshop. Professors are encouraged to make the CT requirements a clear and important part of the class design and syllabus since the explicit pedagogy is associated with large instructional effects (Abrami et al., 2008). Further, professors provide students with a CT skill packet that outlines a one-page summary of the what, when, how, and why of each skill. It is worth noting that faculty members are free to adapt and fine-tune the portfolio as the semester progresses. More recently, it was encouraging for us to read Grosse's (2011) review of the literature of faculty development, which found that the development of teaching portfolios was among the best practices of centers for teaching and learning.

Class Observations

A significant part of this model for faculty development is the inclusion of extensive, direct observational data in place of self-reported data. Our emphasis on observation of instruction stems from Halpern's (1993) recommendation that "an assessment that attempts to identify the specific educational experiences that result in improved CT would require a more fine-grained analysis of instruction" (p. 276).

Most research has focused on the evaluation of instruction through student achievement or self-report from faculty rather than observation of instructors; however, best gains occur in students' CT when extensive observations on course administration and instructors' CT practices were reported (Zohar & Tamir, 1993). In our model, each professor is assigned a student observer who is not taking the class for credit, but is present in each class. The observers receive training (see Appendix B for explanation of training process) and attend every class during the semester to record their observations about the professors' implementation of the infusion method into course content. Student observers and research assistants are given academic credit for the first year of participation, and then are paid for their mentorship of new student assistants the second year and for two months in the summer for writing reports and articles.

The observations are not, in any way, a means of evaluating or scrutinizing whether the faculty member is following the portfolio or teaching effectively. The goal is to provide applicable and supportive feedback to the faculty. Having gone through the process twice , Laura (first author) personally appreciates having the observer present as it frees her during class to engage with her students knowing that someone is there to help her recognize which areas she infuses the skills and dispositions effectively and which areas need additional application.

Informative Feedback Conultations

A comprehensive staff development program can be enhanced by the use of consultations (Grosse, 2011). The director for our program meets with each faculty member, along with the respective class observer, four times during the semester enabling faculty members to develop their pedagogical skills over an extended period of time (Bernstein & Ginsberg, 2009). The consultations help faculty build a knowledge base of CT and instructional strategies and reflect the practicality and comprehensiveness of the approach.

During the consultations, the professors receive a four-page document with the information gathered from the observational list. The document details instructional strengths and provides suggestions for improvement on the embedding of each selected CT skill. The feedback also includes additional graphs to illustrate the average number of times the professor implemented each of the CT pedagogical processes during the previous three weeks. The one-hour consultation provides helpful and constructive feedback; it is imperative that this consultation remains a collaborative effort where faculty members are not being evaluated at any level.

Final Report

At the end of the semester, the professors receive a final report containing a statistical analysis of the results, which includes the statistical significance and effect sizes for students' net growth from pre-test to post-test in both CT skills and dispositions. The final report enables professors to assess their own pedagogy in infusing CT and reevaluate their goals and teaching strategies for the following semester. Although professors are encouraged to maintain the same CT skills during the second semester of implementation, they may choose to drop a skill that was difficult to integrate or add a skill that seems better suited to the curriculum.

Continuation of CT Implementation

Professors' official participation in the CT program typically (although not required) extends for two to three semesters. Some teachers may choose to participate longer, particularly if the professors decide to infuse CT into an additional course. Infusion of CT in a new course requires the development of a new portfolio of skills and a uniquely integrated curriculum. Once professors complete official participation in the program, the professors no longer receive consultations, classes are not observed by student researchers, and no pre-test/post-test measures are administered. However, the professors are encouraged to continue CT instruction using the materials they have developed through the program and to continue evaluating students' CT through CT-infused course assignments and tests.

Second Part:
Quantitative Inquiry on the Impact of Facutly Development

In order to address Bélanger et al.'s (2011) findings, which stated the need for assessment that examine the impact of faculty development, we decided to include the assessment of two aspects of the training:

> 1) How helpful/effective were the consultations? We assessed whether the faculty members' use of specific CT pedagogy changed after receiving direct feedback through the consultations.
>
> 2) To what degree did professors' experience with this model of CT pedagogy affect students' gains? We distributed the faculty in three categories of experience level: *Novice* faculty had gone through one semester of training, *experienced* faculty had two, and *expert* faculty had a minimum of three semesters of CT training.

Method

Participants

Participants in this inquiry included 15 professors employed at a small liberal arts university in the Midwest who volunteered to participate in a training program to infuse CT into course content. Data were collected from 45 semester-long classes taught by these professors during the spring of 2012 to the spring of 2015. The four female and 11 male professors ranged from the age of 29 to 69, with 12 having their PhDs and four having been awarded teaching awards. The ranking of the professors included two adjuncts, three assistant, five associate, and six full professors. The participating professors taught both lower-division and upper-division courses, and the average class size was 20. The professors represented 10 departments: exercise science, psychology, computer science, theater, mathematics, biblical studies, English, social work, finance, and masters of higher education. The 904 students taught by these participating professors during the specified time frame ranged from freshman to senior academic status.

Procedure

A team of five to six student researchers, led by Stephen (second author), the program director, was responsible for collecting class observations, administering measures, entering and analyzing data in SPSS, and presenting consultations to the program director and participating professor three times per semester. Each student researcher assumed primary responsibility for one class per semester.

Data Collection and Measures

Data Collection and Analysis: Impact of Consultations

In order to investigate the impact of consultations on professors' use of CT pedagogy during each quarter of the semester, consultation data was compiled from 24 participating classes. All semesters and departments included in the overall data set were represented within this sample. Overall percentage means were recorded for the professors' use of each of the six pedagogical practices during each consultation period. Consultation means are not cumulative but rather represent the professors' inclusion of CT pedagogy during only one quarter of the semester's instruction.

To analyze whether professor use of CT pedagogy significantly increased after the teacher received observer feedback during the first consultation (Table 1), Andrea (third author) conducted a one-way repeated measures analysis of variance (ANOVA**)** on first and second consultation means.

The primary measurement device used to assess each teacher's instruction of CT was an "observation checklist" with 87 indices. The observation checklist was developed from a review of the literature on teaching CT and a semester of pilot study observations. The measure included eight overarching categories that consisted of (a) explicit instruction (not included in this study), (b) implicit instruction (not included in this study), (c) critical dialogue, (d) transfer instruction, (e) guided modeling and practice, (f) metacognitive instruction, (g) evaluative instruction, and (h) dispositional instruction. For each instance in which the professors utilized one of these techniques, they received one tally mark on the observation checklist (see Appendix C).

Table 1
Impact of Consultations on Professor Use of CT Pedagogy

Pedagogical Process	First Consultation		Second Consultation					
	M	*SD*	*M*	*SD*	*n*	F(2, 22)	*P*	η^2
Dialogue	0.70	0.27	0.82	0.26	24	5.73	.025*	.200
Transfer	0.54	0.25	0.66	0.28	24	4.11	.054	.152
Modeling	0.44	0.24	0.55	0.29	24	5.24	.032*	.186
Metacognition	0.30	0.18	0.44	0.25	24	8.48	.008**	.269^{+}
Evaluation	0.34	0.22	0.46	0.23	24	9.52	.005**	.293^{+}
Dispositional Instruction	0.65	0.28	0.73	0.59	24	0.30	.539	.017

*p < .05. **p < .01. ***p < .001.
$^{+}\eta^2 > .20$. $^{++}\eta^2 > .50$. $^{+++}\eta^2 > .80$.

Data Collection and Analyis: Faculty CT Teaching Experience's Effect on Students' Gains

Students in each class were given the CT skills pre-tests as a take-home assignment during the first week of the semester. The skills post-tests were administered in class during the last week of the semester, and students were given an hour to complete them (for more detail regarding the pre-test and post-test see Appendix D). To demonstrate students' comprehensive mastery of a CT skill, five levels of knowledge were evaluated for each skill: definition, identification, application, metacognitive processes, and metacognitive knowledge. We conducted a one-way repeated measures ANOVA on students' pre- to post-test gains on each level of knowledge.

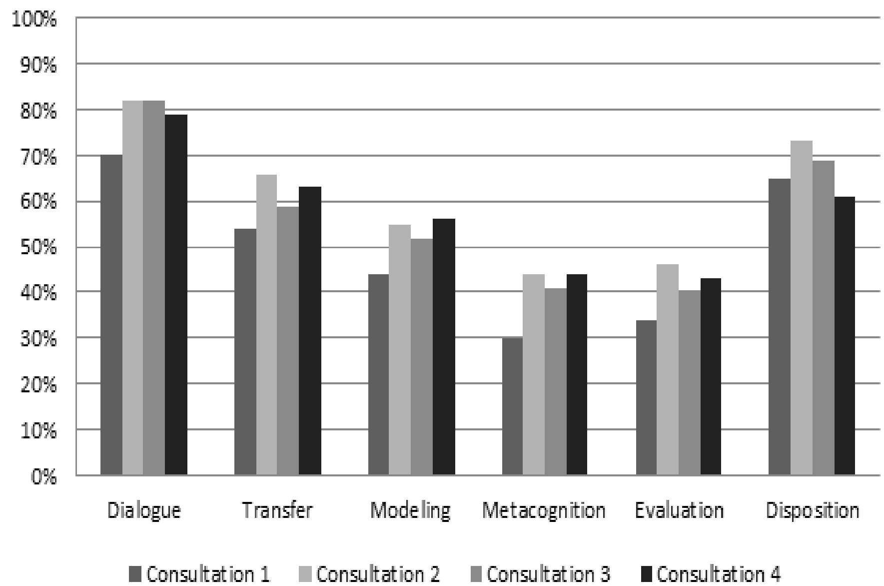
Results

Consultations and Use of CT Pedagogy

Results of the one-way repeated measures ANOVA conducted on the first and second consultations demonstrated statistically significant growth within four categories: dialogue, modeling, metacognition, and evaluation. The change in professors' use of dialogue and modeling was statistically significant ($p < .05$), indicating that there was less than a 5% probability the difference in means occurred by chance. Changes in metacognition and evaluation had both medium statistical significance ($p < .01$) and low practical significance ($\eta^2 > .20$).

As illustrated in *Figure 3*, professors experienced the greatest growth in their use of the pedagogical processes between the first and second consultations. Professors continued to use the teaching strategies more frequently during the remainder of the semester after attending the first consultation, indicating that even periodical feedback, when specific, can benefit the development of faculty teaching practices.

Figure 3
Comparison of Professors' Observed Pedagogy



Note. Consultation 1 (n = 24), Consultation 2 (n = 24), Consultation 3 (n = 24), Consultation 4 (n = 16)

Professor Experience and Student CT Gains

In order to assess whether students benefitted from faculty members' continued involvement in a robust CT training program, a one-way ANOVA was conducted to compare student net gains within five levels of knowledge when taught by novice, experienced, and expert professors. Novice professors had one semester of experience teaching CT within a specified course (n

= 224), experienced professors had two semesters ($n = 261$), and expert professors had a minimum of three semesters ($n = 419$). As shown in Table 2, professor experience level was statistically significant for application of CT ($p < .001$), metacognitive processes ($p < .001$), and metacognitive knowledge ($p < .01$); however, results were not practically significant. A post hoc LSD test revealed high statistical significance ($p < .001$) between application and metacognitive processing means of novice and expert professors, as well as experienced and expert professors. Medium statistical significance ($p < .01$) was found between metacognitive knowledge means of novice and experienced professors, indicating that student learning is positively affected when an instructor receives training and feedback through a comprehensive development model that continues beyond a single semester.

Table 2

Effects of Instructor CT Teaching Experience on Student Net Gains

	Novice [a]			Experienced [b]			Expert [c]					
Levels of Knowledge	*M*	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*	*n*	F $(2, n_1)$	*p*	η^2
Definition	0.37	0.27	205	0.35	0.27	197	0.36	0.27	277	0.23	.791	.001
Identification	0.32	0.32	205	0.31	0.33	222	0.30	0.32	261	0.19	.825	.001
Application	0.36	0.27	205	0.33	0.27	229	0.48	0.29	367	23.01	<.001***	.055
Metacognitive Processes	0.37	0.36	205	0.40	0.39	229	0.52	0.36	334	12.85	<.001***	.033
Metacognitive Knowledge	0.32	0.32	205	0.42	0.33	229	.37	0.35	263	4.73	<.01**	.013

Note. The variation in sample size is due to the inclusion of classes that did not assess all levels of knowledge.
*p < .05. **p < .01. ***p < .001.
$^{+}\eta^2 > .20$. $^{++}\eta^2 > .50$. $^{+++}\eta^2 > .80$.
[a]Professor has explicitly taught CT in same course for one semester
[b]Professor has explicitly taught CT in same course for two semesters
[c]Professor has explicitly taught CT in same course for three semesters or more
n_1 degree of freedom varies due to differing *n*

Limitations and Future Research

One limitation of this investigation is the absence of a comparison group consisting of professors who did not receive training in CT instruction. Without a measured baseline, the extent to which CT was already incorporated into our participants' courses remains unknown. The effects of the workshop, mentored instruction, portfolio development, class observations, and feedback consultations were also not observed in isolation; therefore, no causal claims can be made as to the effectiveness of any single element. Further investigations might seek to compare the effectiveness of programs that utilize all five of these elements versus those that offer limited training. For example, to what extent will professors naturally improve in their use of pedagogical processes over the course of the semester if they receive pre-semester training but no informative feedback consultations?

One could also argue that it is not the *number* of times that teachers employ dialogue, transfer, modeling, metacognitive, evaluative, and dispositional approaches, but the *quality* of the implementations used that results in student differences between novice, experienced, and expert instructors. Our current observational assessment cannot quantify variation in the depth of instructional techniques used by each group, and the development of an additional measure is necessary to further explore these differences. Our study also did not control for the potential effects of a post-test grade on student results.

What We Have Learned About the Process

Faculty development is a process and as such fundamentals are essentials to success. Excellence in teaching and learning is a complex and multifaceted endeavor, and we have learned much both from faculty members and students. Following are a set of fundamentals that have produced positive outcomes for us and may benefit those designing and conducting a faculty development program in CT:

- Professors must enter the CT training program voluntarily with a willingness to improve their teaching.
- It is optimum for professors to choose no more than five skills to embed into their course content.
- If possible, have the person in charge of the CT training and mentoring teach a lesser load.

- We learned that faculty members are able to implement the skills seamlessly on their third time in the same course content.
- Consultation feedback enhances professors' progressive growth in CT teaching strategies.
- The right incentives and an appropriate environment must be present. To encourage faculty, they receive a small stipend ($500 per semester) for up to three times participation (i.e., three semesters).
- Using trained student researchers to assist with classroom observations, feedback consultations, and the analysis of student data promotes both the development of students' research skills and the cost-effectiveness of the program.

Implications for Practice

In light of the results of this inquiry, we believe higher education administrators would benefit from investing in robust and long-term faculty development in regards to CT instructional methods. In particular, centers for teaching and learning should consider providing a method for faculty development that includes advanced training in the infusion method, with semester-long mentoring of instructors, class observations, and consistent feedback through consultations, thus supporting faculty in multiple ways.

Students taught by expert professors in the CT training program (i.e., three or more semesters of CT infusion experience) exhibited greater gains than did those taught by novice (one semester of CT embedding experience) or experienced (two semesters of experience) professors. These results posit that students receive maximum benefit from faculty development programs that extend beyond a single semester, even though growth can occur after one semester. This model attempts to move faculty from novice to expert teachers in CT. Our findings are congruent with Berstein and Ginsberg's (2009) recommendations that faculty developers pursue a continuous paradigm of teacher development as best practice, thus improving the scholarship of teaching and learning both within CT-related areas and beyond.

Providing consistent informative feedback to professors on their daily infusion of CT instruction seems to improve their frequency in using the pedagogical practices related to effective CT instruction. Even one consultation, based on observations of three weeks of CT implementation, can significantly improve the amount of integration of CT in the classroom. These findings should be encouraging to institutions where similar CT programs are desired but funds or staff are limited. Although funding may not be available to implement the full program, even limited observations and feedback appear to be helpful.

For instructors whose higher education institution does not provide training, we recommend they intentionally develop their own portfolios following the four steps provided and adopt the teaching strategies presented in *Figure 2*. We believe, from our experience, that students will benefit even from a limited implementation (Snyder et al., in press).

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Appendix A

Sample CT Skills List

Analogical Reasoning	Consulting with Experts	Hypothesis Testing	Prediction
Analysis	Defining a Problem	IDEAL Problem Solving Model	Probability
Analyzing an Argument	Detecting Stereotypes	Identifying Logical Fallacies	Rearrangement
Asking Good Questions	Developing a Procedural Plan	Judging the Credibility of a Source	Searching for a Pattern
Cause and Effect	Developing an Argument	Using Matrices	Similar Problem Fewer Variables
Comparison and Contrast	Diagramming	Means End Analysis	Developing Sub Goals
Compensatory Unequal Weights Decision Making Model	Direct Analogy	Multiple Perspectives	Synthesis
Considering Extreme Cases	Graphing	Operational Definitions	Working Backwards

Appendix B

Training for Student Researchers

Student researchers were recruited by the program director through classroom interactions, peer recommendations, and faculty advising meetings within the psychology department. During their first year of research involvement, new student researchers received six credits of statistical training through enrollment in the fall Applied Psychological Statistics course and the spring Advanced Psychological Statistics course, both taught by Stephen (second author, the program director. The program director has infused CT instruction into both courses for the past several years and modeled CT pedagogical processes through his own teaching, which exposed new student researchers to advanced techniques in CT integration.

The research team typically consisted of approximately six students. At least two students on the team were experienced members in their second year of involvement, and these students provided one-on-two mentoring for new team members. Prior to observing their first class period independently, new 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.

After student researchers completed a year of research experience, they transitioned to mentoring positions for new team members. Additionally, training continued for all student researchers during weekly meetings with the program director. These meetings allowed the program director to discuss program objectives, supervise the collection of pretests and posttests, receive reports of the previous week's progress, and address any individual concerns.

Appendix C

Checklist for Class Observations

The observers fill out a checklist that parallels the workshop training and the portfolio. This checklist gauges the following items: the pedagogy used to teach the CT skills, teaching for transfer, the use of guided modeling, metacognitive instruction, assessment, and dispositional instruction. Each category is then divided into four to six related subcategories to identify specific pedagogical practices. For example, transfer instruction was subdivided into using low transfer and high transfer examples, practicing CT, reinforcing CT, and assigning CT-related homework. Furthermore, credit was given only when the pedagogical techniques pertained to a specific CT skill. Therefore, professors would not receive evaluative credit for assigning a unit test on course content; however, credit would be given if the test simultaneously required students to use the CT skills of diagramming or working backwards within exam questions.

For each instance in which the professors utilized one of these techniques, they would receive one tally mark on the observation checklist. As the goal was for professors to master the breadth of techniques within each category, progress within each category was reported as an overall percentage based on how many sub-techniques they integrated. For example, a professor who incorporated both a low transfer example and a high transfer example into the class lesson and then assigned CT-related homework would receive a score of three out of five categories, or 60%, for that day's overall transfer score.

Appendix C (Continuation)

Checklist for Class Observations

Critical Thinking Strategies

1. IDEAL IMP: ____ EXP: ____

Identify the Problem

2. Elements/Argument IMP: ____ EXP: ___
3. Strength/Argument IMP: ____ EXP: ___
4. Logical Fallacies IMP: ____ EXP: ____
5. Source Credibility IMP: ____ EXP: ____
6. Assumptions IMP: ____ EXP: ____

Define and Represent the Problem

7. Chart IMP: _____ EXP: _____
8. Graph IMP: _____ EXP: _____
9. Diagram IMP: _____ EXP: _____
10. Hierarchical Tree IMP: ____ EXP: ____
11. Matrix IMP: _____ EXP: _____

Exploring Strategies (What)

12. Analogies IMP: _____ EXP: _____
13. Synthesis IMP: _____ EXP: _____
14. Compare/Contrast IMP:____ EXP: ____
15. Analyzing IMP: _____ EXP: _____
16. Multiple Perspectives IMP: ___ EXP: __
17. Cause/Effect IMP: ____ EXP: _____
18. Working Backwards IMP: ____ EXP: ___
19. Pattern IMP: _____ EXP: _____
20. Similar Problem IMP: _____ EXP: _____
21. Categorize IMP: _____ EXP: _____
22. Define Problem IMP: _____ EXP: _____
23. Predict IMP: _____ EXP: _____
24. Op. Definitions IMP: _____ EXP: _____
25. Problem Solve IMP: _____ EXP: _____
26. Good Questions IMP: _____ EXP: _____
27. Hypothesis Testing IMP: ___ EXP: ____
28. Probability IMP: _____ EXP: _____
29. Rearrangement IMP: _____ EXP: _____

Acting on Strategies

30. Procedural Plan IMP: _____ EXP: _____

Looking Back and Evaluating

31. Decision Making IMP: _____ EXP:____

Others:

______________IMP: _____ EXP: _____
______________IMP: _____ EXP: _____

Tallies

Professor (max 25)

(32) Questions	(33) Answers
/25	/25

Student (max 25)

(34) Questions	(35) Answers
/25	/25

C.T. Transfer Instruction (Why)

(36) Application Tech ______
(37) Low Transfer ______
(38) High Transfer _______
(39) Practice CT ________
(40) Reinforce CT_______
(41) Homework________

Excel: /5

C.T. Modeling/Guided Model (How)

(42) Explain Ideas _____
(43) Help Apply ______
(44) Step by Step _____
(45) Break in Smaller Parts ____
(46) Involve Students _____

Excel: /5

C.T. Metacognitive Instruction (When)

(47) Focus on When ______
(48) Indicate When _____
(49) Focus on Thinking ______
(50) Planning ________
(51) Monitoring _______
(52) Assessing ________

Excel: /6

Tallies

Evaluative Instruction

(53) Evaluation of CT ________
(54) Review of CT _________
(55) Quiz/Test _________
(56) Project ________
(57) Mastery System _______

Excel: /2

Dispositional Instruction

(58) General CT Disposition ___
(59) Specific CT Disposition ___
(60) Truth Seeking ______
(61) Open Mindedness ______
(62) Analytical ______
(63) Systematic ______
(64) Inquisitiveness ______
(65) Cognitive Maturity ______
(66) Cognitive Self Confidence ___
(66b) Faith/Learning _______

Excel: / (3 or more)

Comments

Amount of Time

(95) Competition ____
(96) Reflection ____
(97) Audio/Visual ____
(98) Group Work ____

Appendix D

CT Skills Pre-test and Post-test

Student gains in CT were assessed through an objective, short-answer examination of each thinking skill taught during the student's semester course. The assessment was developed based on a comprehensive review of literature and was tested for construct validity prior to use. To demonstrate students' comprehensive mastery of a CT skill, five levels of knowledge were evaluated for each skill: definition, identification, application, metacognitive processes, and metacognitive knowledge. After first defining the skill, students were asked to identify three situations where the skill was applicable and provide a metacognitive rationale for their choice. They were then given a sample application problem specific to the given skill and asked to solve it by recording their progression through each step of the application. Lastly, students were required to note their metacognitive processes during the application procedure by listing the relevant planning, monitoring, and assessing questions they used to solve the problem (Beyer, 1988).

As most professors chose multiple CT skills to teach per class, the majority of students completed a packet containing five to six comprehensive assessments. Skill tests were then graded by trained student researchers using a standardized rubric. Each level of knowledge was weighted to indicate its approximate level of difficulty; for example, students received only two points for a correct definition of the skill but could receive up to 12 points for successfully applying the skill.

In order to communicate to students the importance of their participation in the CT study, professors were encouraged to allot a small portion of the course grade for the student's completion of the posttest. Previous pilot studies conducted by the program director demonstrated that assigning the CT posttest for no credit, extra credit, or as take-home work did not sufficiently motivate students to complete the posttest responses thoroughly, or to prepare for the assessment by reviewing their course notes as they would for course content tests. All pretests, mid-tests, and posttests were collected as hardcopies, graded by student researchers, and then stored in a secure cabinet within the psychology lab. Once data were entered into SPSS, data files and consultation reports were uploaded to an online database where it was accessible to all CT student researchers.