

The Effect of Critical Thinking Instruction on Graduates of a College of Business Administration

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We conducted a quasi-experimental study of a pedagogical treatment in critical thinking in a college of business administration. Significant improvements were obtained in 6 of 7 measures of critical thinking using a validated assessment instrument. Subsequently, we taught this treatment for five years. We then conducted a qualitative/quantitative survey of the graduates of the college who had taken this treatment. Our quantitative results were validated by the qualitative responses of the graduates. The graduates confirmed they transferred the knowledge, skills and strategies they had learned from their undergraduate class in critical thinking into their post-graduation personal, academic, and professional lives.

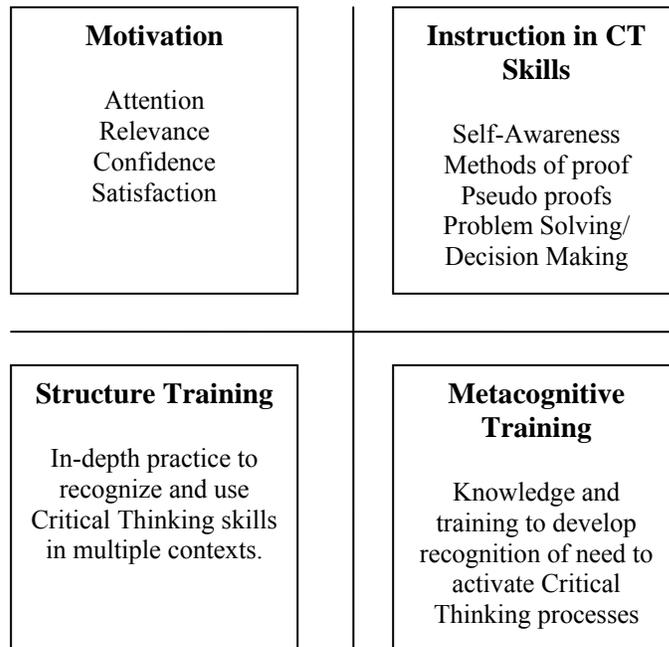
INTRODUCTION

Critical thinking is an essential component of education, and it is an important life skill that everyone should acquire (Case, 2005; Giancarlo, Blohm, & Urdan, 2004). Critical thinking has been defined as, "... the use of those cognitive skills or strategies that increase the probability of a desirable outcome" (Halpern, 1998, p. 450). Reid defined it as, "The conjunction of knowledge, skills, and strategies that promotes improved problem solving, rational decision making and enhanced creativity" (2009, October).

There is ample evidence that this essential knowledge and skill set is not being taught or being acquired (Helsdingen, Bosch, Gog, & Merriënboer, 2010; Marin & Halpern, 2011; Orr et al., 2011a, 2011b; Stupnisky, Renaud, Daniels, Haynes, & Perry, 2008; Willingham, 2007). Devore (2008) reported that, although employers expected that graduates of colleges of business had been taught to think critically, 87% of business school graduates had received no training in these essential business skills. A recent survey of business managers and corporate-suite executives were overwhelmingly unimpressed with the skills acquired by business school graduates (Woods-Bagot, 2012). Leading their list of unacquired skills was problem-solving and critical thinking, along with the inability to work with others. Avrum and Roksa have shown that students in colleges of business administration achieve the lowest scores of all students in the Collegiate Learning Assessment (Arum & Roksa, 2011, p. 104). Further, "We find that individual post-college experiences track with performance at the end of college on an evaluation of their higher-order generic skills measured with the Collegiate Learning Assessment" (Arum, Cho, Kim, & Roksa, 2012, p. abstract).

At the 2010 MBAA International Conference, we reported a quasi-experimental pedagogical investigation involving 55 graduating seniors from a Midwestern college of business administration (Anderson & Reid, 2010, March). Our instructional model was Teaching for Critical Thinking developed by Diane Halpern (1998). Within this context, she proposed a "... model for teaching Critical Thinking skills so they will transfer across domains of knowledge ..." consisting of four constituent elements, as shown in Figure 1, Concept Map of Teaching for Critical Thinking (1998, p. 451). The first component of the TCT pedagogical strategy was the dispositional or attitudinal element. The second was instruction in and practice of critical thinking skills. The third component was structure training to facilitate transfer across contexts or domains. Finally, a metacognitive component was used to direct and assess thinking.

FIGURE 1
CONCEPT MAP OF TEACHING FOR CRITICAL THINKING MODEL



The instructional design model we used was that of Foshay, Silber, and Stelnicki (2003). Borrowing heavily from Merrill (2002, 2007), and from Clark (Clark, Yates, Early, & Moulton, 2006; Kirshner, Sweller, & Clark, 2006), Foshay, Silber, and Stelnicki wrote *Writing Training Materials That Work: How to Train Anyone to Do Anything*. In this book, they describe a five-step model of instructional design that provides a parallel construction to Halpern's model. This model is shown in Table 1. The Cognitive Training Model [CTM] (2003, p. 29)

TABLE 1
THE COGNITIVE TRAINING MODEL

Learners Must Do This to Learn	Trainers Put These Elements in Lessons to Help Learners
<p>1. Select the Information to Attend to: Heighten attention and focus it on new knowledge being taught because that new knowledge is seen as important and capable of being learned</p>	<p>Attention: Gain & focus learner's attention on the new knowledge. WIIFM: What's In It For Me? YCDI: You can do it.</p>
<p>2. Link the New Information to the Existing Knowledge Put the new knowledge into an existing framework by recalling existing / old knowledge related to the new knowledge and linking it to the old.</p>	<p>Recall existing knowledge</p> <p>Relate the new knowledge and the old knowledge.</p>
<p>3. Organize the Information Organize new knowledge in such a way that matches the organization already in mind for related existing knowledge to make it easier to learn, cut mental processing time, minimize confusion, and stress only relevant information.</p>	<p>Structure of Content. Objectives. Chunking. Text Layout. Illustrations.</p>
<p>4. Assimilate the New Knowledge into Existing Knowledge Integrate the new knowledge into the old knowledge so they combine to produce a new unified, expanded and reorganized set of knowledge</p>	<p>Present New Knowledge.</p> <p>Present Examples.</p>
<p>5. Strengthen the New Knowledge in Memory. Strengthen the new knowledge so that it will be remembered and can be brought to bear in future job and learning situations.</p>	<p>Practice. Feedback. Summary. Test. On-the-job application.</p>

We used two different assessments to determine the acquisition of CT skills and of transfer between domains. The primary assessment instrument was the California Critical Thinking Skills Test, which was administered as a pre-test/post-test to the experimental groups and as a post-test to the control group. The secondary assessment was a series of 10-question, T/F quizzes provided by Halpern and Rizzio (2003), which were administered in a pre-test/post-test format with each chapter of the text. These quizzes were developed for use in conjunction with Halpern's book *Critical Thinking Across the Curriculum*, which was the critical thinking textbook in this treatment (1997a).

We used chapter exams derived from Halpern and Riggio to assess learning. The researcher graded these exams and provided them to the instructor. These exams represented five percent of the students' overall grade. The authors developed a third set of assessments to teach the students to use critical thinking within the domain of business, while also providing structure training within the Halpern model. The business textbook contained many excellent case studies (Hill & Jones, 2009). We chose specific case studies, which emphasized the particular topics within that week's critical thinking treatment. We developed a series of rubrics to be used to assess the student's application of critical thinking to the case study. Since the students taking this course were graduating seniors, they were skilled in analyzing case studies. In these instances, not only were they to use SWOT analyses, financial analyses, and other business tools, but also apply the critical thinking skills from the chapter in their analyses. These critical thinking case studies represented another five percent of the students' grade. A full semester case study on a particular company and a computerized business simulation represented forty percent and fifty percent of the student's grade, respectively.

The pedagogical treatment we developed consisted of 11 modules of approximately 1 hour of class time. This corresponded to one introductory module, nine book chapters of the Halpern text, and one wrap-up session. Each module, corresponding to a chapter in the Halpern text (1997a), contained the pre-test/post-test, True/False quiz; a computer-aided, multi-media assisted lecture; a discussion of the previous chapter assignment; a new chapter assignment; an examination on the content of the chapter; and a business case study. The pre-test of the T/F quiz was administered within the first five minutes of the class period. A copy of the PowerPoint lecture, the chapter assignment, chapter examination, post-test T/F quiz, and the business case study were emailed to each of the students. Students returned their examination, quiz, and case study by email prior to the following week's class.

The sample was of three sections of a senior level, capstone course in business administration, two of which were experimental and one was the control. The experimental group (n=34) contained only those students who completed the treatment, the CCTST pre-test, and the CCTST post-test. Twenty-one (n=21) students participated in the control class. Students in the control group and in the experimental group prior to receiving training in critical thinking skills achieved a percentile score of 36 in the CCTST, as compared to all other graduating seniors across the country who had taken this test. Students in the experimental group who completed the course in critical thinking, achieved percentile scores of 51, compared with other graduating seniors assessed with the same test of critical thinking skills. These results are shown in Table 2, Control v Experimental Classes.

TABLE 2
CONTROL V EXPERIMENTAL CLASSES

CCTST	Control (n=21)		Experimental (n=34)	
	Pre-test	Post-Test	Pre-Test	Post-Test
Percentile	*	36.2	36.3	50.7
Total Score	*	14.5	14.6	16.9
Analysis	*	3.8	4.0	4.4
Inference	*	6.9	6.8	8.3
Evaluation	*	3.8	3.6	4.3
Inductive	*	8.2	8.1	9.4
Deductive	*	6.3	6.1	7.5

These results were analyzed statistically to determine if there were significant differences in the pre-test/post-test scores. The results were also analyzed to determine Cohen's d and the effect size, measured as r^2 . These results are shown in the Table 3, Summary of CCTST Pre-Test/Post-Test Statistics.

TABLE 3
SUMMARY OF CCTST PRE-TEST/POST-TEST STATISTICS

Parameter	<i>t</i> -Test	<i>Cohen's d</i>	r^2
Total Score	T(33)=3.057, Significant, $\alpha < .005$	.534 Medium	22.07% Strong
Percentile Score	T(33)=4.600, Significant, $\alpha < .005$	.789 Large	39.07% V. Strong
Analysis	T(33)=1.521, Not Significant	.260 Small	6.55% Medium
Inference	T(33)=3.48, Significant, $\alpha < .005$	.598 Medium	25.85% Strong
Evaluation	T(33)=2.490, Significant, $\alpha < .01$	.427 Medium	15.82% Medium
Inductive	T(33)=3.730, Significant, $\alpha < .005$	.640 Medium	29.66% Strong
Deductive	T(33)=2.860, Significant, $\alpha < .005$	.491 Medium	19.87% Strong

We also analyzed the results of the 10-question, pre-test/post-test quizzes. As part of this analysis, we calculated Cohen's *d* and r^2 . These results are shown in Table 4, Summary of Chapter Pre-Test/Post-Test Statistics.

TABLE 4
SUMMARY OF CHAPTER PRE-TEST/POST-TEST STATISTICS

Module	<i>t</i> -Test	<i>Cohen's d</i>	r^2
1 – Introduction	T(38)=2.72, Significant, $\alpha < .005$	.435 Medium	16.25% Strong
2 – Memory & Knowledge	T(30)=1.807 Significant, $\alpha < .05$	.324 Small	9.81% Medium
3 – Thought & Language	T(38) = 2.673 Significant, $\alpha < .005$	.428 Medium	15.82% Strong
4 – Deductive Reasoning	T(36) = 5.03 Significant, $\alpha < .005$	.827 Large	41.30% V. Strong
5 – Analyzing Arguments	T(37) = 3.224 Significant, $\alpha < .005$	.523 Medium	21.93% Strong
6 – Thinking as Hypothesis Testing	T(36) = 3.526 Significant, $\alpha < .005$	.580 Medium	25.67% Strong
7 – Likelihood and Uncertainty	T(32) = 3.736 Significant, $\alpha < .005$	.650 Medium	30.37% Strong
8 – Problem Solving	T(30) = 4.403 Significant, $\alpha < .005$	.790 Large	39.25% V. Strong
9 – Decision Making	T(27) = 1.996 Significant, $\alpha < .05$	.377 Medium	12.86% Medium
Overall Score	T(312) = 9.360 Significant, $\alpha < .005$	.535 Medium	22.28% Strong

We concluded that critical thinking was taught, was learned, and the skills acquired in the classroom were transferred from the domain of the classroom into the domains of the CCTST and of the business

case studies (Anderson & Reid, 2011, December, 2011, June, 2011, October; Reid & Anderson, 2011, March, 2012a, 2012b). This treatment was so successful that the educator continued to teach it for three more years.

We now report the results of a summative study of the students who took this course and have since graduated. The purpose of this study was three-fold. First, we wanted to determine quantitatively the extent the knowledge, skills, and strategies taught in the treatment were transferred into the personal, academic, and professional lives of the graduates. Second, we wanted to determine the effects of the treatment on the satisfaction of the graduates. Finally, we wanted to determine the feelings and sensibilities of graduates reflecting on the critical thinking treatment and its effects upon them.

LITERATURE REVIEW

For a course of study to be effective, the skills, techniques, and philosophy must be transferred from the classroom and into the lives of the graduates. The problems of transfer have vexed educators and scholars. As all teachers have known since the beginning of instruction, if the lessons learned are not applied by the student, then the instruction did not pass the test of utility in the real world (Sophocles, 450 BCE). Gelder opines:

One of the biggest challenges in learning new skills, particularly general skills such as critical thinking, is the problem of transfer. In a nutshell, the problem is that an insight or skill picked up in one situation is not, or cannot be, applied in another situation. A transfer of acquired knowledge and skills certainly does occur to some extent; otherwise, education would be an exceedingly laborious business. The problem is that it happens much less than one might naively expect. (2005, p. 3)

Halpern and Hakel assert the goal of education is transfer of knowledge from the classroom into the real world.

The purpose of formal education is transfer. We teach students how to write, use mathematics, and think because we believe that they will use these skills when they are not in school. We need to always remember that we are teaching toward some time in the future when we will not be present - and preparing students for unpredictable real world "test" that we will not be giving - instead of preparing them for traditional midterm and final exams. (2003, p. 38)

The failure to transfer the knowledge, skills, and strategies from the classroom into the real world is expressed most eloquently by Halpern. "If we fail to address the fact that too many students leave our classrooms unable to transfer principles and understanding to new domains of knowledge, we will create a work force for tomorrow that is superbly prepared only for yesterday's problems" (1997, p. 26).

To determine whether a course of study was effective, the graduates must be surveyed to determine the extent, type, and conditions under which they use the instruction, and in which aspects of their lives they employ it.

However, it is widely recognized that self-assessments are characteristically flawed. Kruger, and Dunning, and other authors have demonstrated that those in the lowest quintile on a variety of tests, consistently estimate their abilities and their scores to be in the fourth quintile (Dunning, Heath, & Suls, 2004; Ehrlinger, Johnson, Banner, Dunning, & Kruger, 2008; Kruger & Dunning, 1999, 2002). Those who score in the fifth quintile consistently rate their performance in the fourth quintile.

Further research demonstrated that training in critical thinking, of which metacognition is a part, improves the capacities of persons responding to surveys such as ours. In 1999, Kruger and Dunning trained underachieving students to evaluate their own performance, increasing their personal metacognition. These students improved their ability to differentiate their correct answers from their

incorrect answers, concurrently improving their performance (Kruger & Dunning, 1999). Subsequently, they demonstrated similar performance improvements using different tests and controls (Ehrlinger, Johnson, Banner, Dunning, & Kruger, 2008). Finally, Helsdingen, Bosch, Gog, and Merriënboer reported that soldiers trained in critical thinking demonstrated improved command and control decision-making, employing these skills in a variety of situations. They concluded that participants demonstrated deeper understanding of problems enabling them to solve new problems different from those in the training courses (2010).

These miscalculations in both relative and absolute scores were related to the individual's metacognition of their actual abilities. By improving the participants' skills and their metacognitive awareness, they recognized their limitations and improved their ability to estimate their relative and absolute scores. Since one of the outcomes of the critical thinking pedagogical treatment for students is improved metacognition, then we would like to believe that the self-evaluations reported by the graduates were close approximations of their actual status. However, since we cannot be sure, we sought confirmation.

Facione (1990b) conducted a Delphi study, in which 46 experts determined the cognitive skills, dispositional dimensions, and assessments that could be used to measure critical thinking. The results generated by this panel led to the development of the California Critical Thinking Skills Test (Facione, Facione, Blohm, & Gittens, 2008; Facione, 1990a), the California Critical Thinking Disposition Inventory (Facione, 1992), the Holistic Critical Thinking Scoring Rubric (Facione, 1994), and the California Measure of Mental Motivation (Giancarlo & Facione, 2000) among others. In that Delphi study, the panelists agreed on four different methods that could be used to assess a person's critical thinking skills:

In theory there are several ways persons can be judged to be more or less proficient in a given CT skill or at the integrated use of related CT skills.... A third way is to query persons and receive their descriptions of the procedures and judgments they are using as they exercise that skill, would use if they were to perform that skill, or did use when they performed that skill. (p. 31)

In our survey, we included a qualitative component to each of the specific questions. Further, our survey contained three additional questions requesting the graduates' opinions of the strengths, weaknesses, and potential modifications to the course. One use of these answers is strictly qualitative, i.e. to obtain new insights or explore alternate avenues.

We used the graduates' descriptions of the procedures and judgments they reported as assessments of their acquisition and use of the knowledge, skills, and strategies taught in the critical thinking treatment, in accordance with the third of Facione's assessment methods. By using subject matter experts to judge the graduates' responses, we could determine if they were consistent with the principles inculcated in the critical thinking course of study. If the respondents were determined to have used inductive or deductive reasoning processes, including the development of rules, the development of arguments, or the use of disconfirming evidence, while avoiding fallacious arguments and language, then they will be judged to have used critical thinking when providing their Likert-scale response. Thereby, the respondent's qualitative responses would be used to validate the respondent's quantitative responses. We have included such descriptions submitted by the graduates, and the subject matter experts' judgments to confirm the transfer of critical thinking from the classroom into their personal, academic, and personal lives and to confirm their perceived levels of satisfaction with the pedagogical treatment.

METHOD

We obtained valid contact information for 71 graduates. These graduates became the population for this study. Of these, twenty-nine responded, a 41% return. These respondents were our sample.

We developed a survey to provide both quantitative and qualitative information concerning the pedagogical treatment. We used two questions used for screening purposes. Eleven of our questions were

quantitative, based on a 7-point Likert scale. On this scale, 1 was the worst/least/lowest possible score, 7 the best/most/highest possible score, and 4 was defined as neutral. We used this scale to calculate the effects of transfer from the classroom into the lives of the graduates. This relationship is shown in Figure 2, Seven-Point Likert Scale.

**FIGURE 2
SEVEN-POINT LIKERT SCALE**

1	2	3	4	5	6	7
Worst	Worse	Bad	Neutral	Good	Better	Best

We also included qualitative components in these eleven questions, in which respondents were asked to provide their opinions on the subject posed by the question. In addition, three questions were qualitative, asking for the graduate’s opinions on the best and worst parts of the critical thinking treatment, as well as any suggestions for changing, improving, or modifying the treatment.

We tabulated the surveys in a spreadsheet, and performed statistical analyses to obtain the median and standard deviation. We calculated Cohen’s d to determine the effect size. Since the mean of the survey question was defined by the Likert scale, we performed a Z-test on the responses to determine quantitatively the transfer and use of critical thinking knowledge, skills, and strategies by graduates in their personal, educational, and professional lives.

RESULTS AND DISCUSSION

Pre-Graduation vs. Post-Graduation Questions

We asked four questions to explore the opinions of the graduates when they were students as different from their opinions now that they are graduates and working professionals. In the first pair, we explored their opinions regarding their overall opinion of the critical thinking treatment itself. The second pair of questions, we explored their opinions regarding their perceived need to learn to think critically.

Questions 1 and 3: Opinion of the Critical Thinking Treatment

First, we asked the graduates, “At the time you took the unit of instruction in critical thinking, what was your opinion of the critical thinking component in general?” Their mean scores as students were 4.93 with a standard deviation of 1.47, a statistically significant result ($Z=3.28, p=.0005$). The effectiveness of the pedagogical treatment was measured by computing Cohen’s d, which was found to be .63, a medium effect size.

In the third question, we asked, “Since the time you took the unit of instruction in critical thinking, what is your opinion of critical thinking module in general?” The mean scores for this question was 5.41 with a standard deviation of 1.60, which is significant, $Z=4.57, p<.00003$. The effectiveness of the pedagogical treatment was measured by computing Cohen’s d, which was found to be .88, a large effect size.

There was a difference in the means of the responses to the pre-course Question 3 and the post-course Question 5. When this difference were subjected to further statistical analysis, we found it was significant ($Z=1.71, p=.045$). We interpreted the results as revealing that, upon retrospection, the graduates’ opinions of the critical thinking treatment had improved significantly in comparison with their opinions of the treatment as undergraduates.

Questions 2 and 4: Opinion of Their Need to Learn to Think Critically

In the second question, we asked the graduates, “At the time you took the unit of instruction in critical thinking, what was your opinion of your need to learn critical thinking skills and techniques?” The mean

score for this question was 4.67 with a standard deviation of 1.66. This result was statistically significant, $Z=2.08$, $p=.019$. Cohen's d was .40, a medium effect size.

In the fourth question, we asked, "Since the time you took the unit of instruction in critical thinking, what is your opinion of the critical thinking module in general?" The mean score for this question was 5.63 with a standard deviation of 1.52. This result was statistically significant, $Z=5.56$, $p<.00003$. Cohen's d was 1.07, an extremely large effect size.

Again, we subjected the means of questions 2 and 4 to further statistical analyses. We found that the means were significantly different ($Z=3.28$, $p=.005$). Therefore, we concluded with confidence, that upon reflection, the graduates were significantly more cognizant of their need to learn to think critically than they were as ignorant undergraduates confident of their own capabilities while not looking forward to the prospects of additional work in a class.

Qualitative Confirmation of Pre-Post Graduation Responses

R1 wrote, "Everyone needs to learn critical thinking skills. Our younger generations have no clue of how to think for themselves. They don't know how to communicate. How you respond when you are face to face with someone is critical. I'm currently going into Nursing; this field requires a person to use critical thinking." This is a simple argument, with the conclusion, "everyone needs to learn critical thinking skills." The respondent used communications premises primarily, with a strong premise from the domain of nursing to support the conclusion. The development of this argument indicates the use of inductive reasoning. The creation of arguments through the use of deductive reasoning is a key component of the critical thinking process.

R2 wrote, "I really needed to change the way I thought about life in general. This course helped change my life. I returned to school, finished my degree, and (am) now currently working in the medical field that I tried to go into 20 years ago. My critical thinking skills have helped develop me into a wiser person." R2 created an argument, concluding that CT had changed his/her life, with the supporting premises of the return to school, completion of the degree, and current profession. The development of this argument indicated the use of inductive reasoning. The creation of arguments through the use of deductive reasoning is a key component of the critical thinking process.

R3 wrote, "The critical thinking course required much effort on my part. But, as I progressed through the material, I realized how useful it was, and (it) would make me a smarter decision maker." R3 developed an argument, concluding s/he was a smarter decision maker with premises involving hard work, study, and retrospection. The development of this argument indicated the use of inductive reasoning. The creation of arguments through the use of deductive reasoning is a key component of the critical thinking process.

R4 wrote, "Before I took [the] CT course, I was a firm believer that common sense was something that just could not be taught. After taking the course, I am a firm believer that it can be taught by using good old fashion logic and critical thinking." R4 created the argument that s/he had been wrong, citing premises of logic and critical thinking to provide a basis for learning common sense. The development of this argument indicated the use of inductive reasoning. This argument also utilized disconfirming evidence to deny a previous conclusion and to support the new one. The use of disconfirming evidence to develop an argument through the use of deductive reasoning along with the testing of that argument are key components of the critical thinking process.

The subject matter experts determined these responses were representative of, or congruent with, the knowledge, skills, or strategies the graduates learned in the CT treatment.

Academic/Education Question

Question 5: Graduates' Use of Critical Thinking in Other Courses

In this question, we asked the graduates, "Since the time you took the unit of instruction in critical thinking, have you used critical thinking skills and techniques in other classes or courses of study?" The mean score for this question was 5.32 with a standard deviation of 1.52, which is significant, $Z=3.78$, $p=.00007$. Cohen's d was .87, a large effect size. We deduced that the critical thinking treatment was

extremely beneficial, otherwise the students would not be using it in other classes. We concluded, with an extremely high degree of confidence, that the students had used critical thinking in subsequent classes and that transfer had occurred.

Qualitative Confirmation of Educational Question Responses

Again, we confirmed our conclusions with the graduates' qualitative responses, as follows.

R1 wrote, "I utilized this instruction through my two years at (university) and graduated Summa Cum Laude, with a 4.0 GPA." R1's argument concluded that s/he had achieved a 4.0 GPA, based on the premise that s/he had taken the CT course. The development of this argument indicates an attempt to use inductive reasoning. The creation of arguments through the use of deductive reasoning is a key component of the critical thinking process. However, this is a weak argument.

R2 wrote, "I wish I could say every class required it, but one class that helped was Economics." This respondent differentiated between the utility of CT in different academic courses, using an argument and deductive reasoning. The development of this argument indicated the use of inductive reasoning, as well as the use of disconfirming evidence to provide a limiting premise for the argument. The creation of arguments through the use of deductive reasoning as modified by disconfirming evidence, are a key component of the critical thinking process.

R3 opined, "One class that used some more thought to solve problems is Statistics." Similarly, R3 argued that, although CT was not universally applicable, it was valuable in the study of statistics. The development of this argument indicated the use of inductive reasoning, as well as the use of disconfirming evidence to provide a limiting premise for the argument. The creation of arguments through the use of deductive reasoning as modified by disconfirming evidence, are a key component of the critical thinking process.

R4 wrote, "... any student can benefit from the critical thinking techniques found in this course. I recommend the instruction of critical thinking to all students wishing to become better decision makers." R4 concluded that to become a better thinker, a person should take a course in critical thinking. The development of this argument indicated the use of inductive reasoning. The creation of arguments through the use of deductive reasoning is a key component of the critical thinking process.

The subject matter experts determined these responses were representative of, or congruent with, the knowledge, skills, or strategies the graduates learned in the CT treatment. Thereby, they validated the quantitative results with the graduate's qualitative responses.

Profession/Career Question

Question 6: Graduates' Use of Critical Thinking in Their Career or Profession

We asked the important question, "Since the time you took the unit of instruction in critical thinking, have you used critical thinking skills and techniques at work?" The mean score for this question was 5.26 with a standard deviation of 1.56, which is significant, $Z=4.19$, $p<.00003$. Cohen's d , was .81, a large effect size. We deduced that the critical thinking treatment was extremely beneficial, otherwise the graduates would not be using it in their work. We concluded with an extremely high degree of confidence that the graduates transferred the critical thinking knowledge, skills, and strategies from the pedagogical treatment into their professions or careers.

Qualitative Confirmation of Profession/Career Question Responses

We confirmed our conclusions with the graduates' qualitative responses, as follows.

R1 wrote, "To my surprise, forecasting and inventory control and things of that nature requires a lot of critical thinking skills." R1 expressed incredulity that the material learned in the critical thinking course was of use in business. Thereafter, R1 used the premises of forecasting, inventory control, and other business skills as disconfirming evidence, leading to the conclusion that CT was required in business. The development of this argument indicated the use of inductive reasoning, as well as the use of disconfirming evidence to provide a limiting premise for the argument. The creation of arguments

through the use of deductive reasoning as modified by disconfirming evidence, are key components of the critical thinking process.

R2 wrote, "It helps deciding many factors such as staffing needs, budgets, purchasing, and many more aspects of my job." R2 similarly argued for the acquisition of CT, citing premises of staffing needs, budgets and purchasing as premises. The development of this argument indicated the use of inductive reasoning. The creation of arguments through the use of deductive reasoning is a key component of the critical thinking process.

R3 wrote, "Yes ... I sometimes have to do projections in our Fixed Asset System, and the software lets me do a trial and error approach to different 'what if' scenarios." R3 created an argument for the acquisition of CT, developing premises of the acquisition and use of problem-solving or decision-making skills. The creation of arguments through the use of deductive reasoning is a key component of the critical thinking process.

R4 wrote, "The best part of the critical thinking was being able to go through a process to solve problems that required more thought than just assuming the right answer." R4 argued for the acquisition of CT, premising problem-solving or decision making, including seeking disconfirming evidence. The creation of arguments through the use of deductive reasoning and testing the argument using disconfirming evidence, is a key component of the critical thinking process.

The subject matter experts determined these responses were representative of, or congruent with, the knowledge, skills, or strategies the graduates learned in the CT treatment. In so doing, they validated the quantitative results with the graduate's qualitative responses.

Personal Questions

In the next five questions, we asked how the critical thinking treatment had affected the graduates at a personal level. Three of the questions involved the graduate's interactions with others; two required their introspection to determine reasons for changes they observed in their interpersonal activities.

Personal 1: Daily Life

When we asked graduates, "Since the time you took the unit of instruction in critical thinking at the University, have you used critical thinking skills and techniques in your daily life?" their responses were overwhelming in the affirmative. The mean score for this question was 5.78 with a standard deviation of 1.12, which was statistically significant, $Z=8.24$, $p<<.00001$. Cohen's d was 1.67, an extraordinarily large effect size. This extraordinarily positive result indicates that the graduates were transferring the knowledge, skills, and strategies acquired in the classroom into their daily lives. Further, the fact that they are using these skills is an extremely positive indicator of the need for such training. If these skills were not needed, the graduates would not be using them.

Personal 2: Interactions with Others

In the next question, we asked, "Has the unit of instruction in critical thinking you took while at the University affected the way you interact with others?" Again, the responses were enthusiastic, with the mean score of 5.26 with a standard deviation of 1.58. This result was statistically significant, $Z=4.13$, $p<.00003$. Cohen's d was .80, a large effect size. We concluded with a high degree of confidence that the critical thinking knowledge, skills, and strategies very positively affected the graduates' inter-personal relationships.

Personal 3: Perceptions of the World

In the next question, we asked, "Has taking a unit of instruction in critical thinking you took while at the University affected your perceptions of the world around you?" The mean score for this question was 5.48 with a standard deviation of 1.55, which was statistically significant, $Z=4.96$, $p<.00003$. Cohen's d was .95, a very large effect size. This extremely positive result indicates that the graduates not only were transferring the knowledge, skills, and strategies acquired in the classroom into their daily lives, but also using it in their personal perception of the world around them. This is an extremely positive indicator of

the need for such training. Graduates have modified their worldview, using critical thinking skills at the most basic human level.

Personal 4: Perceptions of Oneself

In the penultimate question, we asked each of the graduates, “Has taking a unit of instruction in critical thinking you took while at the University affected your perceptions of yourself?” The mean score for this question was 4.85 with a standard deviation of 1.85, which is significant, $Z=2.39$, $p=.008$. Cohen’s d was .46, a medium effect size. Although positive, this result was more reserved than the responses of the graduates in the previous three questions.

Personal 5: Personal Changes

In the final question, we asked the graduates, “Has the unit of instruction in critical thinking you took while at the University changed you in any way?” These results were similar to those of the previous question. The mean score for this question was 4.93 with a standard deviation of 1.71. This result was statistically significant, $Z=2.82$, $p=.002$. Cohen’s d was .54, a medium effect size. Although we concluded that the positive results indicated the graduates were aware of changes in their perspective, at least in part attributing them to their perceptions of self, we were concerned with the differences in the scores of the first three of the personal questions as compared with the last two questions.

We tested the means of these five questions to determine if they were statistically different. We found that the mean of Personal 1 was significantly different from Personal 4 ($Z=4.29$, $p<.00003$) and significantly different from Personal 5 ($Z=3.95$, $p=.00005$). Similarly, Personal 3 was significantly different from Personal 4 ($Z=2.11$, $p=.017$), and also from Personal 5 ($Z=1.86$, $p=.034$).

These results confirmed our observations, but did not help us to determine the reasons for the cognitive dissonance the graduates are reporting. Is it possible that the graduates are very satisfied with their external interactions, including their daily lives, perceptions and interactions, while less satisfied with the changes in themselves? Do they view their own changes as a necessary price to be paid for changes in other aspects of their lives? Is this just an expression of modesty, false modesty, or reticence to admit to being pleased with the changes they have experienced? Perhaps the changes that the graduates have experienced have been sufficiently slow and gradual, that they did not realize that they had changed or that their perceptions had changed. As such, intimations that they have been changed by the critical thinking treatment may not be as satisfying as their changes in external relations. They might even be ashamed, viewing their changes as a necessary price to be paid for changes in other aspects of their lives. Regardless, this is an interesting phenomenon, which deserves to be studied.

Qualitative Confirmation of Personal Question Responses

We confirmed our conclusions with the graduates’ qualitative responses, as follows.

R1 wrote, “It helps me look outside the box for other answers/solutions to decisions I need to make.” R1 used the creative strategy of a change of perspective, leading to new methods of solving problems or the making of decisions. The use of creative strategies is the ultimate level of the critical thinking process.

R2 stated, “I see the world differently. Instead of going for the surface, I tend to go deeper and look to the core.” R2 used inductive reasoning, deductive reasoning, and argument to detect, evaluate, and understand meaning, rather than accept surface appearance. This is also an example of the use of disconfirming evidence used to seek alternate arguments to those obvious on the surface. The creation of arguments through the use of deductive and inductive reasoning, as modified by disconfirming evidence, is a key component of the critical thinking process.

R3 opined, “It usually only takes me a moment to recognize when someone lacks the ability to respond with a logical reply.” R3 combined language skills and argument to analyze the cogency of other people’s responses. Analyzing words and arguments to determine fallacies is an important aspect of the critical thinking process.

R4 admitted, “I am not saying that I am not naïve anymore, but I know I am a lot less naïve now.” This was easily the most insightful of all the responses we received. R4 recognized that s/he had acquired

skills, but was not yet an expert in their use. Such a nuanced analysis is an excellent example of the critical thinking process.

R5 noted, "I try to analyze a situation from a different point of view when necessary." R5 referred to the use of creative skills taught to develop new perspectives in solving problems or making decisions. Creative thinking is the highest level in the critical thinking process.

R6 wrote, "I have always been known as a person who thinks a lot what to do before I do things, but after I took this course it had help me a lot. I not only think before I do things, but now I think everything in a different perspective." R6 used deductive reasoning to develop an argument. The argument posited before and after states of taking the CT course. R6 conclude that s/he was acting more creatively, because of the application of critical thinking skills. This is an example of the use of deductive reasoning to create a logical argument, both of which are key components in the critical thinking process.

R7 summarized his/her experience, as follows, "The best part of the critical thinking treatment was breaking apart ideas that were held to be 'truth' and finding out there are holes in that belief and possibly no validity to them." R7 used inductive and deductive reasoning methods, including examples of pseudo-arguments, to seek out disconfirming evidence to invalidate previously held convictions. Each of these is components of the critical thinking process. Together, they demonstrate a degree of mastery of that process.

Each of these responses was representative of, or congruent with the knowledge, skills, or strategies the graduates learned in the critical thinking treatment. We determined these responses were representative of, or congruent with, the knowledge, skills, or strategies the graduates learned in the CT treatment.

Aggregate

Finally, the values of all the responses for all the questions were aggregated, and analyzed in the same manner as were the responses from individual questions. The mean score for the aggregate sum of all the questions was 5.22 with a standard deviation of 1.57. This result was statistically significant, $Z=12.05$, $p<<.00001$. Cohen's d was .77, a large effect size. We concluded that the aggregated total of all the responses from all of the graduates demonstrated transfer of the critical thinking knowledge, skills, and strategies from the pedagogical treatment into every aspect of their lives.

The results of this quantitative survey are shown in Table 5, Statistics for Quantitative Questions.

TABLE 5
STATISTICS FOR QUANTITATIVE QUESTIONS

	Mean	S.D.	Z-Score	Cohen's d
Q1	4.93	1.47	Z=3.28 Significant, p=.0005	.63 Medium
Q2	4.67	1.66	Z=2.08 Significant, p=.019	.40 Medium
Q3	5.41	1.52	Z= 4.57 Significant, p<.00003	.88 Large
Q4	5.63	1.52	Z=5.56 Significant, p<.00003	1.07 Huge
Education	5.32	1.52	Z=3.78 Significant, p=.00007	.87 Large
Work	5.26	1.56	Z=4.20 Significant, p<.00003	.81 Large
Personal 1	5.78	1.12	Z=8.24 Significant, p<<.00001	1.59 Huge
Personal 2	5.26	1.58	Z=4.13 Significant, p<.00003	.80 Large
Personal 3	5.48	1.55	Z=4.96 Significant, p<.00003	.95 Large
Personal 4	4.85	1.85	Z=2.38 Significant, p=.008	.46 Medium
Personal 5	4.93	1.71	Z=2.82 Significant, p=.002	.54 Medium
Aggregate	5.18	1.59	Z=12.81 Significant, p<<.00001	.74 Large

CONCLUSION

Our study has shown that the pedagogical treatment was extremely successful in transferring the knowledge, skills, and strategies of critical thinking from the classroom into a variety of environments. Graduates report statistically significant transfers of critical thinking from the classroom and into their personal lives, their jobs, and their education. The graduates described their use of critical thinking in their personal, academic, and professional lives. These descriptions and reasoning were congruent with the critical thinking model taught in the pedagogical treatment. Their descriptions of the knowledge, skills, and strategies they were using in their personal, academic, and professional lives confirmed that they were using what they had learned, thereby acting as an appropriate assessment of their abilities and capabilities.

It might be argued that the qualitative responses simply reflect the quantitative results, in that the respondents might presume the desired responses sought by the survey. There was no evidence of bias inherent in the results, while there is ample evidence that the graduates were well considered in their responses.

Supporting Argument 1

First, in pairs of Questions 1 & 3 and Questions 2 & 4, the graduates clearly differentiated between their opinions of the critical thinking treatment before they had taken it and their opinions some time later and after graduation. The difference between the means of the pairs of pre-post graduation was statistically significantly for both pairs of questions. This evidence, combined with that of their qualitative responses, indicate the graduates took the time and effort to critically assess their states of mind, and that they responded accordingly.

Supporting Argument 2

This line of reasoning is further supported by the observations of the graduates. It must be remembered that these graduates had taken this course one to four years prior to this survey. If the knowledge, skills, or techniques taught in a course of study are not used by the student, then they are quickly forgotten. Yet, these practicing professionals, often several years removed from school, asserted that they are using critical thinking. Furthermore, they supported their responses with words, phrases and examples that were consistent with the critical thinking processes as contained in the pedagogical treatment.

Supporting Argument 3

Further, we see a statistically significant differentiation between the graduates' responses regarding their interactions with others and their perceptions of themselves. If they were attempting to provide responses that were perceived to be the desired ones, would they not have provided similar, strongly positive responses to questions regarding personal changes as they had towards interpersonal ones? Their qualitative responses are clear and explicit explanations of their use of critical thinking, and the situations in which they use it. The graduates even recognize their limitations or inconsistencies in their use of critical thinking, which is a clear demonstration of their reasoning ...the final proof of their critical thinking acumen.

Earlier in this paper, we quoted that the purpose of education is transfer (Halpern & Hakel, 2003, p. 38). The graduates who responded to this survey have confirmed clearly and unambiguously that they have transferred knowledge, skills, and strategies they learned as undergraduates into their personal, educational, and business lives. Based on this evidence, we conclude that our critical thinking pedagogical treatment is an outstanding success.

FUTURE STUDIES

We have concluded that graduates who had received the pedagogical treatment in critical thinking had transferred the knowledge, skills, and strategies from the classroom environment into their personal, academic, or professional lives. Since the goal of education is transfer of knowledge from the classroom into the person's real life, we also concluded that our critical thinking pedagogical treatment was successful. However, several aspects of this study have not yet been considered.

When we considered the results of the personal questions, the graduates were very positive in asserting that they had transferred critical thinking into their daily lives, their interactions with others, and their perception of the world. Yet, the graduates demurred from concluding that the critical thinking treatment had changed them as individuals. Statistical analyses confirmed that these differences, but did not help us to determine the reasons for the apparent cognitive dissonance. What is the reason for the cognitive dissonance the graduates are reporting? Since the graduates report significant differences in their daily lives, their perceptions of the world, and their interactions with others, to what do they attribute these differences? To hold that they, as individuals, have not changed is illogical. This is an interesting phenomenon, which deserves to be studied.

This survey is congruent with student satisfaction models. Considered through that lens, this survey's answers might be evaluated to seek evidence of student satisfaction by graduates. Unlike post-semester 'smile sheets,' filled out by students at the end of each course, these results are from graduates, who are

experiencing and reflecting upon the results of their education. Since this is a quantitative survey, real evidence might be generated concerning the effect of the critical thinking pedagogical model on graduates' satisfaction with their education, its applicability to their careers, and its application in their daily lives.

We recognize the limitations of this study. This report covers four years of students, who have graduated, and who now use their educational, business, and life experiences to guide them. Yet, this is a small number of people, all from one college of one Midwestern university. This treatment may not be applicable to any other college, population, or curriculum. In this regard, we encourage our colleagues in other institutions to continue this research. We especially encourage others to explore the cognitive dissonance we discovered in this study.

Our long-term study is compelling evidence of a successful pedagogical treatment in critical thinking. The results of our studies must be considered by curriculum committees at colleges and universities. Critical thinking can be taught, can be learned, and can be transferred from the classroom into other domains. Critical thinking changes the way graduates perceive the world, perform their jobs, and interact with others. The reasons critical thinking is not taught in colleges and universities are unidentified. However, the continued intransigence of institutions of higher education towards teaching critical thinking and applying it throughout the curriculum is as incomprehensible as it is inexplicable.

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