

THE DEVELOPMENT, IMPLEMENTATION, AND EFFECTIVENESS OF A PEDAGOGICAL TREATMENT FOR THE TEACHING AND LEARNING OF CRITICAL THINKING

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Abstract

A quasi-experimental study of a pedagogical treatment in critical thinking was undertaken in a college of business. The quantitative results demonstrated significant improvements in 6 of 7 measures of critical thinking using a validated assessment instrument. This treatment was taught in the college of business for four years. A qualitative/quantitative survey was taken of the graduates of the college who had taken this treatment. Quantitative results were validated by the qualitative responses of the graduates. Graduates were confirmed to use the critical thinking knowledge, skills and strategies they had learned in their personal, academic, and professional lives. Graduates were also shown to be highly satisfied with the effects of the treatment in their personal, academic, and professional lives.

Phase 1: Initial Research into a Critical Thinking Treatment Development of the Critical Thinking Treatment

Critical thinking has been defined as, "... the use of those cognitive skills or strategies that increase the probability of a desirable outcome" [1]. Reid [2] defined it as, "The conjunction of knowledge, skills and strategies that promotes improved problem solving, rational decision making and enhanced creativity." Critical thinking is recognized as an essential part of education and a valuable life skill [3, 4]. However, there is little evidence that critical thinking is being taught or that critical thinking skills are being learned. Federal studies have equated American's poor reading skills, mathematics skills and understanding of scientific principles with inadequate critical thinking skills [5-8]. Winn [9] emphasized these failures, enumerating the high costs of the ineffective teaching of critical thinking. Case [3] stated that he is disheartened by the failures to teach critical thinking.

In our original study, the research question was, can critical thinking be taught? This question has been debated for many years and by numerous authors. Many authors are convinced that it cannot be taught. Some attempt to prove that critical thinking cannot be taught [10]. Some cite the necessity of domain knowledge [3, 11]. Others suggest the problem is the relegation of the teaching of critical thinking skills to so-called lower-order skills [12]. Still others suggest the problem is the lack of teacher's critical thinking skills [13], or teachers' refusal to incorporate critical thinking into their classroom instruction [14]. One suggests that the problem lies in conflicts between sophisticated explanations provided by critical thinking as opposed to intuitive explanations developed in childhood [15]. In a personal communication, Dr. Ken

Silber of Northern Illinois University declared that nobody who had tried to demonstrate that critical thinking can be taught and learned had succeeded [16]. In his words, they "... hadn't moved the needle."

However, other authors suggested that, if the proper methods are employed, then critical thinking skills could be learned. Facione, Facione, and Giancarlo reasoned that, "... given the empirical results, an effective approach to teaching for and about thinking must include strategies for building intellectual character" [17]. Facione discussed the needs for training in critical thinking skills and also for developing the disposition for critical thinking [18]. Diane Halpern has written extensively regarding the teaching of critical thinking and its acquisition by students [1, 19-24]. Leppard opined that 30 years of research and scholarship supported the view that critical and creative thinking can be taught if appropriate instructional strategies were used [25]. Vermunt asserted "...the results indicate that in order to bring about constructive and independent learning behavior, instruction should be mainly aimed at developing self-regulated control strategies and mental learning models in students in which the construction and use of knowledge are central" [26].

Few researchers had reported validated results of efforts to teach critical thinking skills. This lack of validation was one of the underlying causes of skepticism regarding the teaching or learning of critical thinking skills. One of the few to present such a validated study was Westbrook [27], who reported significant gains in logic and reasoning using descriptive learning techniques, as measured by Lawson's Seven Logic Tasks and Lawson's Classroom Test of Scientific Reasoning. Combs [28] reported that cooperative learning increased students' scores in the Iowa Tests of Basic Learning. Tiwari, Lai, and Yuen [29] used the California Critical Thinking Disposition Inventory to demonstrate that students involved in Problem-Based Learning achieved higher scores in Overall Improvement, Truth Seeking, Analyticity, and Critical Thinking Confidence. In pharmacology, Abbate [30] used the ATI critical thinking Assessment to find weak trends towards improved Explanation, Inference, Evaluation, and Self-Regulation along with a weak positive relationship to overall critical thinking. However, none of these researchers demonstrated improved critical thinking skills deriving from instruction in critical thinking.

The initial research problem was to determine whether critical thinking could be taught and learned. This required the development and implementation of a course of study in critical thinking, since no such course was extant. Therefore, a sound theoretical foundation in critical thinking was the first requirement

in the development of such a course of study. Secondly, an instructional design model was needed to provide the pedagogical content and structure to develop and implement such a course of study. Third, a valid and reliable assessment was needed to measure any acquisition of critical thinking skills that might occur. Fourth, a sufficiently large number of test subjects had to be located and who would agree to participate in the course and research study.

The first need was satisfied by the extensive literature generated by Dr. Diane Halpern, Director of the Berger Institute for Work, Family, and Children at Claremont McKenna College, Past President of the American Psychology Society, and noted expert in the field of critical thinking. In 1989, she published, *Thought And Knowledge - An Introduction to Critical Thinking*, describing in exquisite detail the technical parameters of critical thinking. However, this tome was not only large and intimidating, but ill-suited for use as a textbook. Subsequently, Halpern published *Critical Thinking across the Curriculum: A Brief Edition of Thought and Knowledge* [22]. Her reasons for writing this condensed version were to have it serve as a "... companion text that can be used in virtually any course where critical thinking is valued. It can also stand alone for use by anyone who wants to know what cognitive psychologists and educators have found that 'works' to improve learning, remembering, thinking and knowing" [22]. However, even a condensed version of *Thought and Knowledge* proved to be both dense and challenging. Further, she had provided no philosophical foundation or content structure for its use in a classroom.

In 1998, Halpern provided the theoretical content and structure of such a course of study, which she called "Teaching for Critical Thinking" [1]. Halpern defined the goal of "Teaching for Critical Thinking" [TCT] as "... to promote the learning of transcontextual thinking skills and the awareness of and ability to direct one's own thinking and learning" [1]. 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. 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.

Of these four, the first three were well-understood components of courses of study and instructional design strategies. However, the fourth, metacognitive training, was somewhat unusual. Yet, Diane Halpern [1] had asserted that, although it is difficult, the teaching of critical thinking is a matter of a properly developed and implemented curriculum. She stressed that metacognition is one of the four requirements for the teaching of critical thinking. Halpern also asserted that the use of cues and other scaffolding techniques leads to specific metacognitive strategies to solve problems and to make decisions.

Hacker and Dunlosky [31] defined metacognition as knowledge that people have about thought processes as well as individual monitoring and control of their thoughts. Winne [32] averred that metacognition and self-regulated learning are related in their functions, but admitted that the problem of transfer remains. Chen and Bradshaw [33] studied strategies of using scaffolding to integrate knowledge and improve problem solving. They determined that cueing and scaffolding were important mechanisms leading to the development of metacognitive processes.

Haidt [34], expanding on Zajonc's [35] affective principle, reported that the older, more intuitive portion of the human brain was used in most daily activities, because it was automatic, intuitive, and fast. In contrast, there was a newer portion of the brain, which was a slower but more powerful modern brain, used in advanced

cognitive processes. They asserted that the human brain operated at the intuitive level, until some cognitive dissonance engaged the higher brain functions to solve unusual or more difficult problems.

The educational processes of cueing and scaffolding have been shown to lead students to recognize intuitively the need for engaging higher-level mental processes when the cognitive dissonance occurs. This intuitive awareness of the cognitive dissonance is the first step in the metacognitive process. Once the intellectual brain is engaged, the skilled student should recognize the need to engage the metacognitive processes acquired, leading to analysis, fact finding, skeptical inquiry, hypothesis formation, and, ultimately, solutions to everyday problems.

But, it is that mental prompt ... that interruption in the daydream of routine existence that is needed to engage the higher thought processes. Azevedo & Hadwin [36], Chen & Bradshaw [33], and Azevedo, Moose, Greene, Winters & Cromley [37] reported that cueing and scaffolding were educational mechanisms that would create that needed mental nudge. If that mental nudge were to be directed toward previously learned metacognitive processes, then critical thinking would be initiated. As long as the metacognitive structure is useful and useable, then that process should continue towards a personally satisfactory conclusion.

We are warned, however, that the best laid plans of mice and men, "... oft gae alee" [38]. So it is with the engagement of cognitive processes. In addition to Hacker and Dunlosky's [31] warning that not all metacognition is created equal, we must consider Cao and Neitfeld [39], who demonstrated that even though High School and college students were aware of alternate metacognitive strategies, they revert to older, less constructive cognitive strategies in spite of their recognition of the failures of those strategies.

However, these problems were addressed in Halpern's four-part Teaching for Critical Thinking curriculum [1], emphasizing training in the structural aspects of problem solving and decision making. As an integral part of these scaffolding processes, students must understand the consequences of backsliding. They must be confident in their own minds that they can utilize the newer strategies, and they must believe that their implementation of these strategies will lead to greater personal success.

Although Halpern presented both a construct and structure, it was essential to translate that into instructional content. Foshay, Silber and Stelnicki [40] provided the needed instructional design methodology. Borrowing heavily from both Merrill [41, 42] and Clark [43, 44], Foshay, Silber and Stelnicki wrote *Writing Training Materials That Work: How to Train Anyone to Do Anything* [40]. In this book, they describe a five-step model of instructional design that provides a parallel construction to Halpern's model.

However, the objective of this study was to assess quantitatively the students' acquisition of critical thinking skills. Because of limitations of time and sample size, a quasi-experimental approach was chosen for this study, involving pre-test/post-test assessments. Two separate pre-test/post-test assessments were required, both of which were recommended by Diane Halpern.

The first assessment was the California Critical Thinking Skills Test, also recommended by Diane Halpern [21]. This test derived from a pioneering effort by Peter Facione [45] in which he convened a Delphi panel of 46 scholars and educators. The California Critical Thinking Skills Test had undergone vigorous testing, evaluation and validation. The assessment instrument used five scales to measure critical thinking Skills: Inductive Reasoning, Deductive Reasoning, Analysis, Inference, and Evaluation, along with measures of Total Score and Percentile Score relative to other graduating seniors. Individual and group results were reported both as numeric values and as histograms.

The CCTST was used in two different ways. In the first instance, the CCTST was used as a pre-test/post-test in both of the experimental classes to determine if critical thinking skills had been acquired. In the second instance, the CCTST was used to determine the difference between the acquisitions of critical thinking skills in the experimental classes relative to the CT skills acquired in the control class.

The second quantitative assessment instrument was a 10-question, True/False, Chapter quiz provided by Halpern and Riggio [24]. These quizzes fulfilled the requirements of a quasi-experimental, pre-test/post-test protocol. The tests were comprehensive for each chapter. They were intended to test the student's knowledge. They were designed by and published in Halpern and Riggio's text, intended to be used in conjunction with *Critical Thinking Across the Curriculum* [22], the main CT text for the researcher's pedagogical treatment.

The venue for the course of instruction was a senior class in business administration at a Midwestern university. However, the instructor required that the course be integrated into the established course of study and reflect business problems and solutions. The researcher and the instructor worked together to add content to the course, derived directly from the business textbook.

The textbook used in the business course contained a large number of case studies [46]. Some were very large and extensive. These were selected as major projects for the students. Others were very short, mini-studies that emphasized chapter or section content. The researcher and the instructor reviewed these mini-studies, considering them not only for their business content but also for their alignment with the different modules of the critical thinking course of study. These case studies were used to emphasize the need for and use of critical thinking in the domain of business, making the course in critical thinking congruent with the needs of the instructor and the college of business.

A final criterion for the course in critical thinking was that it had to fit into the time and content of the overall business course. The primary instructor allocated one to one-and-one-half hours out of the three hour twenty minute class period. Roughly, 30 to 45 minutes was scheduled to the critical thinking treatment. About one-half hour was devoted to the CT/Business case study. The remaining time was allocated to computer simulations, business course discussions, and other business course content. When both the researcher and the instructor were satisfied that the course would fulfill the needs of the students, the college, the instructor and the researcher, the pedagogical treatment was implemented within the business course of study.

Results and Discussion of Critical Thinking Study

The results of this study exceeded our expectations. Although we had assumed that there would be some improvements in the students' critical thinking skills, we expected to find minimal increases in a few of the parameters of the assessments. We were quite unprepared for the actual results.

Experimental vs. Control Samples:

Thirty-four students volunteered to undertake the experimental critical thinking pedagogical treatment. Twenty-one students acted as the control group. Both groups were graduating seniors in the capstone course, receiving otherwise identical instruction by the same instructor. The only difference was that the experimental groups also received instruction in critical thinking.

We found that the *t*-Scores in six of the seven parameters of the CCTST were significantly different for the two groups. The Control group had scores virtually identical with the pre-test scores of the Experimental group in every parameter of the CCTST. The post-test scores of the Experimental group were significantly higher than the scores of the Control group in six of the seven parameters

of the CCTST. Based upon these results, we concluded that business course had no effect on the students' critical thinking scores

Results of the California Critical Thinking Skills Test

We analyzed the scores from the Experiment group statistically to determine the effect of the critical thinking pedagogical treatment as assessed by the CCTST. We performed a *t*-Test to determine if the post-test scores were statistically higher than the pre-test scores. Since we were performing a *t*-Test, we also calculated the Cohen's *d*, to determine the strength of the statistic. Finally, we performed an *R*² calculation to estimate the effectiveness of the treatment.

Our analysis demonstrated that the post-test scores were significantly higher in six of the seven parameters of the CCTST (Figure 1). Only the Analysis scores were not significant. The Cohens' *d* for the significant scores were all medium to large, indicating the overall strength of the statistical analysis. The *R*² values were medium to very strong, indicating that the treatment was responsible for the significant differences between the pre-test and post-test scores.

Figure 1. CCTST Results

Parameter	T-Test	Cohen's d	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	.26 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 10-question, T/F quizzes taken by the students before and after reading and studying each chapter of the textbook. This analysis would provide insights into the step-by-step learning processes, as well as indicate areas of strength and weakness within the pedagogical treatment.

We found that the difference between the pre-test and post-test scores were statistically significant for every chapter/module. Cohen's *d* was medium for most of the modules, indicating that the *t*-Scores were valid. And, the *R*² was medium to strong, with two chapters being very strong, indicating that the treatment was very effective.

Results of the CT Chapter Assessments

In general the performance of the students in the chapter assessments was poor. The students who showed the most interest in class were those who achieved the highest grades, while those who objected to the extra course content earned low grades. We concluded that the students ignored these chapter assessments since they would have a minimal effect on their grade.

Results and Discussion of Business Course Studies

CT-Case Studies

The Mini-Case Studies obtained from the textbook usually highlighted one or two specific business problems. Students supplied a one-page analysis of the business problem including a well-reasoned solution. The instructor noted consistent attempts by the students to incorporate the CT topic into these case studies, but the student's grades were disappointing. We concluded that the students ignored these case studies since they would have a minimal effect on their grade.

Semester Case Studies

The Semester Case Studies obtained from the textbook were extensive historical reviews of specific corporations, including their business strategies and the specific tactics used to address their business problems. Students developed a 15 to 20 page case analysis of the corporation, which included materials from other sources. These reports included well reasoned analyses of the corporation's strategies, tactics and business solutions. The instructor observed that the results of the Semester Case Study analyses were more thoughtful and more reasoned than those of previous classes. Student grades in this area improved in comparison with previous courses in which critical thinking was not included.

Computer Simulation

The CapSim® simulation from Capsim Management Simulations, Inc.® (Capsim®) is an extensive computer simulation of complex, competitive business operation. Ideally, the student management teams have eight weeks of practice simulation rounds, and eight weeks of competition rounds. This simulation requires that student teams make business decisions in most operational business areas, against up to five competitive businesses. This requires in-depth evaluation of competitor's actions as well as decisions of their company's manufacturing, capacity and scheduling, product R&D, pricing, labor relations and contract decisions, product mix, accounting, and capital investments in a competitive environment. The simulation is intense, and tests the students' accumulated knowledge and integration of business concepts. Commonly, some student teams perform well in the simulation, while many teams fail to consider all of the variables, and, as a result, are forced out of business, or into bankruptcy.

The instructor observed that the results of the CapSim® analyses were more thoughtful and more reasoned than those of previous classes. Teams that had undergone the critical thinking regimen had no business failures. There were varying levels of success, but all teams performed satisfactorily. Student grades in this area improved in comparison to those in previous courses.

Conclusion of Business Course Study

In the reasoned judgment of the senior member of the faculty, there is a strong indication that the critical thinking treatment significantly improved the students' analytical skills and student outcomes.

Results of the Critical thinking Pedagogical Treatment

Our study indicated that our critical thinking course, developed with behavioral-cognitive protocols, such as those proposed by Foshay, Silber and Stelnicki [40], employing Halpern's Teaching for Critical Thinking, was effective in teaching critical thinking skills to undergraduate seniors. These results show that critical thinking skills can be taught and learned. Using Ken Silber's nomenclature, the needle was moved!

Our study also indicated that domain knowledge was not required to learn critical thinking skills. Although efforts were made both by the researcher and the business course instructor to integrate critical thinking skills within the business curriculum, the wide variety of questions and problem-solving skills required by the CCTST did not include those of the domain of business or of the logical processes involved in the acquisition of critical thinking skills. These findings indicate that the students in this sample successfully acquired and then transferred the knowledge and skills they gained in the course of study to the CCTST assessment questions.

The instructor verified that the students had successfully used their CT skills in the analyses of their weekly business course case studies. The instructor also verified that the students had used the CT skills they had acquired to assess the tactics and strategies employed in case studies of their assigned corporations. We

interpreted these results as the successful transference of the skills initially learned within the domain of the CT treatment into the domain of business.

Phase 2: Implementation and Deployment of the Critical Thinking Treatment

Having demonstrated that critical thinking could be taught, learned, and transferred from one domain to another, and that this transfer improved student success, we implemented it. Initially, the treatment was implemented in the capstone course. But, at the suggestion of many students, it was transferred into the communications course. This change was well-considered. Historically, communications courses emphasized content, but not process. Students learned how to draft letters, memos, resumes, reports, presentations, and the like. However, communications courses did not teach the thinking processes that should precede communication. That is, students were taught how to say it, but not what to say.

Critical thinking fulfilled that need. Critical thinking instructed the students in the knowledge, skills, and strategies needed to use language, develop arguments, eschew pseudo-arguments, employ deductive and inductive reasoning, and implement probability to solve problems, make decisions, and find alternative approaches to intransigent business problems. Students were instructed in the use of critical thinking to determine what they were going to communicate. Then, they would use the more standard courseware to implement the proper method and medium to convey the communication. And, the critical thinking content became a major grade component.

During this time, the critical thinking pedagogical study underwent some changes, as suggested by the students in the initial and in subsequent classes. One of the major changes was to split two of the longer and less cohesive chapters in the textbook, resulting in 12 modules rather than 10 chapters.

The second change involved the greater use of electronic media. Rather than handling great quantities of paper documents, assignments were provided to the students via e-mail. Students responded by e-mail, speeding up the processes and providing tracking of documents. In its final configuration, the critical thinking pedagogical treatment was transferred to a Blackboard® format, which could be easily controlled by the instructor and accessed by the students. However, the basic content of the course, the quizzes, and the chapter exams remained intact from the original study.

We took advantage of this three-year period to publish the results of our study [47-52]. We also continued the development of the treatment, including a full semester course of study and a web-based course. We developed specialized courses for industries and for college faculties.

Phase 3: Summative Study of the Critical Thinking Treatment

Introduction to the Summative Survey of Graduates

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. 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. [53]

However, 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 [54]. 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.[55]

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

After three years, we felt we had a sufficient number of students who had taken the critical thinking treatment and who had graduated to ask about their use of critical thinking in their daily lives. The purpose of our 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, or 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.

However, it is widely recognized that self-assessments are characteristically flawed. Kruger and Dunning [57-60] have demonstrated that those in the lowest quintile on a variety of tests, consistently overestimate their abilities and their scores. Those who score in the top quintile consistently rate their performance lower relative to other scores. However, once they know they are overestimating the capabilities of others and underestimating their own, they can determine their absolute scores with reasonable accuracy.

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 [1, 33-35], then we would like to believe that the self-evaluations reported by the graduates was a close approximation of their actual status. However, since we cannot be sure, we sought confirmation.

Facione [45] 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 [61, 62], the California Critical Thinking Dispositions Inventory [63], the Holistic Critical Thinking Scoring Rubric [64], and the California Measure of Mental Motivation [65], 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 (emphasis added).

... 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...*[45]

Other research has shown 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 [57]. Subsequently, they demonstrated similar performance improvements using different tests and controls [60]. 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 [66].

In our survey, we included a qualitative component with each of the quantitative 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 was strictly qualitative, i.e. to obtain new insights or explore alternate avenues. The second use of these answers was to determine the graduates' descriptions of the procedures and judgments they used as assessments of their acquisition and use of the knowledge, skills, and strategies taught in the critical thinking treatment. We have included such descriptions submitted by the graduates to substantiate the transfer of critical thinking from the classroom into their personal, academic, or personal lives and to confirm their perceived levels of satisfaction with the pedagogical treatment.

This type of summative research and statistical analysis is seldom performed. Often, such efforts are exhausting with lots of data, but with few real conclusions. However, in order to gain acceptance of critical thinking as the basis for education, and to provide evidence that students want such a course of study, it must be shown that graduates who have studied it use the skills, knowledge, and strategies in the daily, working, and/or professional lives. Further, it is important to such a study that students recognize that critical thinking not only has merit, but is a powerful skill set that they need, and that educational institutions should be providing.

Method

Seventy-one graduates, who had taken the critical thinking pedagogical treatment and had graduated with a bachelor's degree from the college of business one to three years prior to this survey, became the population for this study. Of these, twenty-seven responded, a 38% return. These graduates became the sample for this study. That is three out of eight members of the population took part in this survey, an extraordinarily large representation.

A survey was developed to provide both quantitative and qualitative information concerning the pedagogical treatment. Two questions were used for screening purposes. Eleven 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. This scale was used to calculate the effects of transfer from the classroom into the lives of the graduates.

These eleven questions also had a qualitative component, 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.

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

To calculate the respondents' satisfaction, we applied an alternate Likert scale. The Likert scale used to calculate the statistical information was named the STAT Scale. The alternate scale used to calculate graduate satisfaction was named the SAT Scale. The relationship between these two scales is shown in Table 1. STAT & SAT Scales.

Table 1.
Seven-point Likert Scale

SAT	-3	-2	-1	0	+1	+2	+3
	Worst	Worse	Bad	Neutral	Good	Better	Best
STAT	1	2	3	4	5	6	7

Using this scalar, we defined three parameters of satisfaction: Strength, Breadth, and Depth. We defined strength as the numerical difference between the mean score of the question and the neutral mean of the survey. We defined breadth of satisfaction as the ratio between the number of graduates with a positive satisfaction and those with a negative satisfaction. We defined depth of satisfaction as the ratio between the positive weighted values and the negative weighted values. The weighted values were calculated by multiplying the number of respondents that selected a value by the value as shown in the Likert scale. We developed an interval scale, which produced a consistent set of values that we could sum and average to produce an overall satisfaction score. We defined the overall satisfaction score as the average of the strength, depth, and breadth scores, as shown in Table 2, Relationship of Scale Value to Strength, Breadth, Depth, and Graduate Satisfaction Score

Table 2.
Relationship of Scale Value to Strength, Breadth, Depth, and Graduate Satisfaction Score.

Scale	1	2	3	4	5
Strength	<1	<1.25	<1.5	<1.75	≥1.75
Breadth	<2	<4	<6	<10	≥10
Depth	<2	<4	<6	<10	≥10
GS	<1.9	<2.9	<3.9	<4.9	≥5
	Moderate	Satisfied	Very	Extremely	Elated

For instance, a strength score of 1.4 would be assigned a scale value of 3. A breadth score of 3.5 would achieve a score of 2, while a depth score of 4.9 would rate a score of 3. The average of these

scores is 2.7, which is a Graduate Satisfaction score of 2, designated as Satisfied

Results and Discussion

Pre-Post Graduation Questions

Questions 1 and 3

We used four questions to explore the opinions of the graduates as students as different from their opinions as graduates. First, we asked the graduates about their opinion of the critical thinking treatment at the time they took the course as undergraduates.

The 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. This result indicates that as students the graduates had a slightly positive attitude towards the learning of critical thinking skills before they undertook this unit of instruction.

The predominant score for this question was 5. The scores of 4 and 6 were second, with 7 and 3 the third most common. Of all the questions, this was the most symmetrical of all the distributions. The strength of the response was calculated as .88. The breadth of satisfaction was calculated from the sums of the negative and the positive scores. Sixteen scores were positive, while 4 were negative. That is, 4 times as many graduates were satisfied with the critical thinking treatment than were dissatisfied. The depth of satisfaction was calculated using the Seven-point Breadth/Depth Scale. The weighted value of all the negative scores was -6, and the weighted value of all the positive scores was 29. The difference was +23. That is, the depth of the graduates' satisfaction with the critical thinking treatment was 5 times higher than the depth of their dissatisfaction. We concluded that, as students, the graduates were satisfied with the critical thinking course

Then, we asked the graduates their opinion of the treatment now that they have had the time and experience to reflect on the treatment. The mean scores for this question was 5.41 with a standard deviation of 1.60, which is significant, $Z=5.41, p<.00003$. The effectiveness of the pedagogical treatment was measured by computing Cohen's d, which was found to be .88, a large effect size. This positive result indicates that the graduates had a much higher opinion of the course than they had as students about to undertake it.

The predominant score for this question was 7. The score of 6 was second, with 4 and 5 the third most common. The strength of the response was calculated as 1.60. The breadth of satisfaction was calculated from the sums of the negative and the positive scores. Nineteen scores were positive, while only 3 were negative. That is, more than 6 times as many graduates were satisfied with the critical thinking treatment than were dissatisfied. The weighted value of all the negative scores was -5, and the weighted value of all the positive scores was 40. The difference was +35. That is, the depth of the graduates' satisfaction with the critical thinking treatment was 8 times higher than the depth of their dissatisfaction. We concluded that the graduates were very satisfied with the critical thinking treatment.

The difference between the responses to Questions 1 and 3 was significant ($Z=1.71, p=.045$). Although this difference is significant, it is minimal, and might bear further study.

Questions 2 and 4

In the second set of pre-post graduation questions, we asked the graduates about their perception of their need for instruction in critical thinking when they were students about to take the course. The mean score for this question was 4.67 with a standard deviation of 1.66. This result was statistically significant, $Z=2.08$,

$p=.019$. The effectiveness of the pedagogical treatment was measured by computing Cohen's d , which was found to be .40, a small effect size. This tepid result indicates that the critical thinking treatment was marginally accepted by the undergraduate students.

The predominant score for this question was 4. The rest of the scores were scattered, showing no particular pattern. The strength of the responses was calculated as .67. The breadth of satisfaction was calculated from the sums of the negative and the positive scores. Thirteen scores were positive, while 3 were negative. That is, more than 4 times as many graduates were satisfied with the critical thinking treatment than were dissatisfied. The depth of satisfaction was calculated using the SAT Scale. The weighted value of all the negative scores was -7, and the weighted value of all the positive scores was 26. The difference was +19. That is, the depth of the graduates' satisfaction with the critical thinking treatment was 3.7 times higher than the depth of their dissatisfaction. We concluded that the graduates were satisfied with the critical thinking treatment, as students.

Then, we asked about their present opinion of their need for the critical thinking course. The mean score for this question was 5.63 with a standard deviation of 1.52. This result was statistically significant, $Z=5.56$, $p<.00003$. The effectiveness of the pedagogical treatment was measured by computing Cohen's d , which was found to be 1.07, a huge effect size. This very positive result indicates that the critical thinking treatment was strongly beneficial for graduates.

The predominant scores for this question were 7 and 5. The score of 6 was the third most common. The strength of the responses was calculated as 1.64. The breadth of satisfaction was calculated from the sums of the negative and the positive scores. Twenty-two scores were positive, while only 2 were negative. That is 11 times as many graduates were satisfied with the critical thinking treatment than were dissatisfied. The depth of satisfaction was calculated using the SAT Scale. The weighted value of all the negative scores was -4, and the weighted value of all the positive scores was 48. The difference was +44. That is, the depth of the graduates' satisfaction with the critical thinking treatment was 12 times higher than the depth of their dissatisfaction. We concluded that the graduates were extremely satisfied with the critical thinking treatment.

Again, the means of Questions 4 and 6 were significantly different ($Z=3.00$, $p=.0013$). Therefore, we concluded with great confidence, that graduates recognized their need for instruction in critical thinking, even though they had not as undergraduates.

Qualitative Confirmation of Critical Thinking

We used the responses of the graduates to confirm their use of critical thinking processes and procedures. One graduate used a logical argument, "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." A second graduate used the following logical argument, "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 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." A third also used deductive reasoning to conclude, "The critical thinking course required much effort on my part. But, as I progress through the material, I realized how useful it was, and would make me a smarter decision maker." The fourth provided a logical argument to disprove his/her previously held conviction: "Before I took Dr. Anderson's critical thinking 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." We interpreted these

arguments, analogies, or statements as representative of or congruent with the knowledge, skills, or strategies the graduates learned in the critical thinking treatment.

Educational Question

We asked the graduates to rate their use of the knowledge, skills, and strategies they had learning in the critical thinking treatment in their other academic pursuits. The mean score for this question was 5.32 with a standard deviation of 1.52, which is significant, $Z=3.78$, $p=.00007$. The effect size of the test was measured by computing Cohen's d , which was found to be .87, a large effect size. This positive result indicates that students generally used critical thinking in other courses that they undertook. 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.

We also calculated the degree of graduate satisfaction with the critical thinking treatment. We found the strength of satisfaction was +1.32; the breadth ratio was 3.5:1, while the depth ratio was 7:1. This was a notable result, because of the large difference between the breadth ratio and the depth ratio. In most questions, the two ratios are similar in size. In this question, however, the graduates with the negative scores were only slightly dissatisfied, while those with positive scores were enthusiastic in their assessment of their satisfaction with the effects of the critical thinking treatment. We concluded that the graduates were satisfied that the treatment was beneficial to their subsequent academic programs.

Qualitative Confirmation of Critical Thinking

Again, we confirmed the graduates' critical thinking with their own words. One used the following logical argument: "I utilized this instruction through my two years at (university) and graduated Summa Cum Laude, with a 4.0 GPA." A second used deductive reasoning to support a logical argument: "I wish I could say every class required it, but one class that helped was Economics." A third used this logical argument: "One class that used some more thought to solve problems is Statistics." A fourth logically argued, "... 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."

Profession/Career Question

Another important question we asked of the graduates to evaluate their use of the knowledge, skills, and strategies they learned in the critical thinking treatment in their professions or careers. The mean score for this question was 5.26 with a standard deviation of 1.56, which is significant, $Z=4.20$, $p<.00003$. The effectiveness of the pedagogical treatment was measured by computing Cohen's d , which was found to be .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.

The strength of the graduates' responses was calculated as 1.26. The breadth ratio was 6, and the depth ratio was 7. Based on these scores, we conclude that the graduates were very satisfied that the knowledge, skills, and strategies they had acquired in the critical thinking pedagogical treatment were beneficial in their business or career.

Qualitative Confirmation of Critical Thinking

We confirmed that graduates were using critical thinking from their own words. One used three premises to support their conclusion: "To my surprise forecasting and inventory control and things of

that nature requires a lot of critical thinking skills.” A second used multiple premises to conclude, “It helps deciding many factors such as staffing needs, budgets, purchasing, and many more aspects of my job.” A third used problem-solving skills to conclude, “Yes (I use CT at work), 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.” A fourth used disconfirming evidence to logically argue, “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.” We interpreted these arguments, analogies, or statements as representative of or congruent with the knowledge, skills, or strategies the graduates learned in the critical thinking treatment.

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.

Question 7

When we asked graduates if they used critical thinking in their daily lives, their responses were overwhelming in the affirmative. The mean score for this question was 5.78 with a standard deviation of 1.12. This result was statistically significant, $Z=8.24$, $p<.00001$. The effectiveness of the pedagogical treatment was measured by computing Cohen’s d , which was found to be 1.59, 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.

The graduates’ strength of satisfaction was 1.78, the highest in the survey. The depth ratio was an extraordinary 24:1, while the breadth ratio was even higher, at 49:1. This is the second question, in which there was a large difference between the depth-scores and the breadth-scores in this question. One difference between this and the earlier question was that only one person expressed a negative satisfaction, and that level of dissatisfaction was minor. The other twenty-six respondents enthusiastically expressed very high levels of satisfaction, completely out of proportion to their numbers. Based on these scores, we conclude that the graduates were elated with the powerful effect the critical thinking pedagogical treatment had on their daily lives.

Question 8

In this question, we asked if the treatment had affected their interactions 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, $Z=4.13$, $p<.00003$. The effectiveness of the pedagogical treatment was measured by computing Cohen’s d , which was found to be .80, a 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 interactions with other people. This is a very positive indicator of the need for such training. Graduates have modified their intrinsic methods of interaction with others, using critical thinking skills at the most basic human level. We concluded with a high degree of confidence that the critical thinking knowledge, skills, and strategies very positively affected the graduates’ interpersonal relationships.

The graduates’ strength of satisfaction was +1.26. The depth ratio and the breadth ratio were both 7:1. Based on these scores, we conclude that the graduates were very satisfied with the effect that

the critical thinking pedagogical treatment had on their interactions with others.

Question 9

In the next question, we asked if the critical thinking treatment had affected the graduates’ perceptions of the world around them. The mean score for this question was 5.48 with a standard deviation of 1.55, which was statistically significant, $Z=4.96$, $p<.00003$. The effectiveness of the pedagogical treatment was measured by computing Cohen’s d , which was found to be .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. We concluded with a high degree of confidence that the critical thinking knowledge, skills, and strategies very positively affected the graduates’ inter-personal relationships.

The graduates expressed high levels of satisfaction, with a strength score of +1.48. Similarly their breadth ratio of 7:1, and their depth ratio of 9:1, expressed high levels of satisfaction. Based on these scores, we conclude that the graduates were very satisfied with the affects of the critical thinking pedagogical treatment on their perceptions of the world around them.

Question 10

In the penultimate question, we asked each of the graduates if the critical thinking unit of instruction had affected their personal perception of themselves. The mean score for this question was 4.85 with a standard deviation of 1.85, which is significant, $Z=2.39$, $p=.008$. The effectiveness of the pedagogical treatment was measured by computing Cohen’s d , which was found to be .46, a medium effect size. Although positive, this result was more reserved than the responses of the graduates in the previous three questions. The levels of satisfaction were also lower. The strength score was only +0.80, the breadth ratio was 3:1, and the depth ratio an anemic 2.8:1. These positive results indicate that the graduates have integrated the critical thinking skills into their basic mindset and worldview. And, we concluded that the graduates were moderately satisfied with the positive affect the critical thinking pedagogical treatment had on their perceptions of themselves.

Question 11

In the final question, we asked the graduates if the treatment had affected them 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, $Z=2.82$, $p=.002$. The effectiveness of the pedagogical treatment was measured by computing Cohen’s d , which was found to be .54, a medium effect size.

Similarly, the strength score was only +0.93. The breadth ratio was only 4:1, while the depth ratio was just 3.5:1. 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, and that the graduates were moderately satisfied that the critical thinking pedagogical treatment resulted in personal changes to themselves, 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 Question 7 was significantly different from Question 10 ($Z=4.29$, $p<.00003$) and different from Question 11 ($Z=3.94$, $p=.00005$). Similarly, Question 9 was significantly different from Question 10 ($Z=2.11$, $p=.017$), and also from Question 11 ($Z=1.88$, $p=.034$).

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 by 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 Questions

Again, we confirmed the graduates' understanding and use of critical thinking, based on their statements. One used a creative solution: "It helps me look outside the box for other answers/solutions to decisions I need to make." A second used inductive and deductive reasoning, as follows: "I see the world differently. Instead of going for the surface, I tend to go deeper and look to the core." A third used the combination of language skills and argument to make decisions: "It usually only takes me a moment to recognize when someone lacks the ability to respond with a logical reply." A fourth was most perceptive, arguing, "I am not saying that I am not naïve anymore, but I know I am a lot less naïve now." The fifth reflected on the use of creative skills to develop new perspectives: "I try to analyze a situation from a different point of view when necessary." The sixth created a deduction comparing before and after states: "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." The seventh graduate used deductive reasoning as well as pseudo-arguments, 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." We interpreted these arguments, analogies, or statements as representative of or congruent with the knowledge, skills, or strategies the graduates learned in the critical thinking treatment.

Aggregate

Finally, the scores for Question 1 through 11 from all the graduates were aggregated to determine the overall distribution of all responses to all the questions. The mean score for these questions was 5.22 with a standard deviation of 1.57, which is significant, $Z=12.07$, $p<<.00001$. The effect size of the test was measured by computing Cohen's d , which was found to be .74, a large effect size. These results are shown in Table 3, Aggregate Scores.

The graduates' single greatest response to all the questions was a score of 5. The scores of 6 and 7 were second. The strength of the responses was calculated as 1.22. The breadth of satisfaction was calculated from the sums of the negative and the positive scores. One hundred seventy-three scores were positive, while 31 were negative. That is 5.6 times as many graduates were satisfied with the critical thinking treatment than were dissatisfied. The depth of satisfaction was calculated using the SAT Scale. The weighted value of all the negative scores was -57, and the weighted value of all the positive scores was 352. The difference was +295. That is, the depth of the graduates' satisfaction with the critical thinking treatment was 6.2 times higher than the depth of their dissatisfaction. We concluded that on aggregate the graduates were very satisfied with the critical thinking treatment.

Table 3.
Aggregated Scores

	Mean	S.D.	Z-Score	Cohen's d
Q1	4.93	1.47	$Z=3.28$, $p=.0005$	.63
Q2	4.67	1.66	$Z=2.08$, $p=.019$	.40
Q3	5.41	1.52	$Z=4.57$, $p<.00003$	.88
Q4	5.63	1.52	$Z=5.56$, $p<.00003$	1.07
Q5	5.32	1.52	$Z=3.78$, $p=.00007$	.87
Q6	5.26	1.56	$Z=4.20$, $p<.00003$	.81
Q7	5.78	1.12	$Z=8.24$, $p<<.00001$	1.59
Q8	5.26	1.58	$Z=4.13$, $p<.00003$	.80
Q9	5.48	1.55	$Z=4.96$, $p<.00003$	.95
Q10	4.85	1.85	$Z=2.38$, $p=.008$	.46
Q11	4.93	1.71	$Z=2.82$, $p=.002$	.54
Overall	5.18	1.59	$Z=12.81$, $p<<.00001$	.74

Conclusion

Our survey showed 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 from the classroom and into their personal lives, their jobs, and their education. Further, our calculations of strength, breadth ratios, and depth ratios provide statistically compelling evidence that graduates were very satisfied with the critical thinking pedagogical treatment.

The graduates described their use of critical thinking in their personal, academic, and professional lives. These descriptions and judgments were congruent with the critical thinking model taught in the pedagogical treatment. Their descriptions confirmed that they were using the knowledge, skills, and strategies they had learned in their personal, academic, and professional lives, fulfilling the need for an appropriate instrument to assess their abilities and capabilities.

It might be argued that the qualitative responses simply reflect the quantitative results, in that the respondents could be aware of the desired responses the survey was seeking. There was no evidence of bias inherent in the results, while there is ample evidence that the graduates were well considered in their responses. First, the graduates clearly differentiated between their opinions of the critical thinking treatment before they had taken it and now, several years later. The difference between the means of the pairs of pre-post graduation was statistically significantly for both pairs of questions. This is evidence that the graduates took the time and effort to consider their states of mind, and they responded accordingly.

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, here we have practicing professionals often several years removed from school, asserting that they are using critical thinking, and supporting their responses with words, phrases and examples that are almost out of a textbook.

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 ...a proof of their critical thinking.

Earlier in this paper, we quoted that the purpose of education is transfer [55]. 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 recognize the limitations of this study. This report covers three 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.

However, these long-term studies are 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 it and applying it throughout the curriculum is as incomprehensible as it is inexplicable.

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