Teaching Critical Thinking Skills In Higher Education: A Review Of The Literature

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ABSTRACT

The authors reviewed 42 empirical studies of teaching of critical thinking skills in postsecondary education published between 1994 and 2009. The instructional intervention, test measure, and research design of the studies were analyzed. Study results suggest that: (1) the same instructional interventions can lead to different results, depending on the intervention's implementation; (2) qualitative data can inform researchers about intervention effects that are not easily captured by quantitative instruments; and (3) most studies reviewed are subject to limitations in research design, sample size, or sample representativeness. The following recommendations are made: (1) statistical significance should not be the only criterion for instructors to consider when choosing new teaching methods; (2) multiple test measures, including quantitative and qualitative, should be used to assess changes in students' critical thinking skills; (3) future research should properly address internal validity threats, e.g. by adopting at least a quasi-experimental design, in order to establish causal relationship between intervention and changes in students' critical thinking skills.

Keywords: critical thinking; postsecondary education; research methodology

INTRODUCTION

Cultivating students' critical thinking skills is a major goal of American higher education (Roth, 2010). Most educators agree that it is essential that students develop such skills while engaged in academic learning because they enable students to engage in purposeful, self-regulatory judgment. Using critical thinking helps students evaluate the arguments of others and their own, resolve conflicts, and come to well-reasoned resolutions to complex problems (Allegretti & Frederick, 1995). Educational institutions often put much effort on "what to think rather than how to think" (Daud & Husin, 2004, p. 478). Changing instructional approaches from what to think to how to think would require a major shift in thinking about instructional paradigms. This type of change would require academics to think about how they could develop students' critical thinking skills through teaching disciplinary content. Reviewing studies that have attempted to facilitate students' critical thinking skills during instruction is one avenue that can promote inquiry and dialogue.

Advancing critical thinking skills also relates to higher education's goal of building responsible citizens. An increasingly complex society requires individuals to base their judgments and decisions on careful evaluation of evidence. Coupled with expectations to make timely and oftentimes immediate decisions, this is especially salient given the exponential amount of available information and individuals' need to reflect on what they decide to believe or to do (Renaud & Murray, 2008). Teaching students higher-order cognitive skills, including critical thinking, can help individuals improve their functioning in multiple circumstances (Tsui, 2002).

Researchers and educators generally agree about the importance of teaching critical thinking skills in higher education. However, they debate if and how such skills could be promoted through instruction (Tsui, 2002). One controversial issue is whether critical thinking is discipline specific. Some experts argue that critical thinking instruction is only effective when it is integrated in teaching subject specific knowledge and skills. Others believe that critical thinking skills are a generalized subset of skills that should be taught separately (Ennis, 1989). A large number of empirical studies have examined the effect of different teaching strategies and interventions aiming at promoting critical thinking skills among college students. However, the findings regarding whether teaching these

skills in context are effective remain inconclusive. For example, some empirical studies using the same type of instructional intervention yield different statistical results (Yang & Chou, 2008; Arburn & Bethel, 1999). Several reviews of studies on teaching critical thinking skills have been published (Abrami, Bernard, Borokhovski, Wade, Surkes, Tamim, & Zhang, 2008; Gibbs, 1985; McMillan, 1987; Powell, 1987; Tsui, 1998; Pithers & Soden, 2000; Brunt, 2005a). However, few studies have focused on how teaching critical thinking skills in higher educational settings affects student outcomes. The lack of insight on this topic suggests that a review of recent empirical studies on the topic of instructional interventions of critical thinking skills may yield important and timely findings.

WHAT IS CRITICAL THINKING?

Definitions

Glaser (1942), a psychologist, defines critical thinking as an attitude and logical application of skills in problem-solving contexts. Ennis (1962) defines the construct as a logical process and product-oriented phenomena, while characterizing it as the correct assessment of statements. Current conceptualizations suggest that critical thinking is a process of purposeful reflection that requires logic (Brookfield, 1987; Ennis, 1989; Paul, 1992; Sternberg, 1986). From the mid-1990s to the present, researchers have maintained that critical thinking is dependent on pre-dispositions and purposeful reflection (Ennis, 1993; Facione, 1990; Paul, 1997). However, even as early as Glaser, researchers have suggested that dispositions were integral to this construct. Experts debate whether critical thinking can be learned, or if it is a developmental process regulated by motivations, dispositions, and personality traits. Despite differences of opinion, contemporary researchers agree that critical thinking is "purposeful, self-regulatory judgment which results in interpretation, analysis, evaluation, and inference, as well as explanation of the evidential, conceptual, methodological, criterialogical or contextual considerations upon which judgment is based" (Facione, 1990, p. 2).

Regarded as intellectually engaged, skillful and responsible thinking that facilitates good judgment, critical thinking requires the application of assumptions, knowledge, competence and the ability to challenge one's own thinking. Critical thinking skills require self-correction, monitoring to judge the reasonableness of thinking, and reflexivity. When using critical thinking skills, individuals are capable of stepping back and reflecting on the quality of that thinking. Simpson and Courtney (2002) point out that critical thinking processes require active argumentation, initiative, reasoning, envisioning, analyzing complex alternatives, and making contingency-related value judgments.

According to Banning (2006), critical thinking involves scrutinizing, differentiating and appraising information as well as reflecting on the information that will be used to make judgments and inform clinical decisions. Brookfield (1987) asserts that identifying, challenging, and analyzing assumptions for validity are essential. Because critical thinkers possess curiosity and skepticism, he opines that they are more likely to be motivated to provide solutions that resolve contradictions.

Psychologists and philosophers differ in their beliefs as to whether critical thinking skills can or cannot be taught. However, Sternberg (1990), Ennis (1989), and Lipman (1988) do not believe that critical thinking skills are a fixed entity. Instead, they claim that they are a form of intelligence that can be taught. The ability to develop critical thinking skills may be likened to Piaget's concrete and formal operations since stages of cognitive development are linked to intellectual potential and environmental experiences (Ornstein & Hunkins, 2004). When students have not reached the formal operations stage their ability to use critical thinking skills is likely to be limited by an inability to handle abstract ideas. However, if learning environments are crucial to developing students' critical thinking skills, what instructional strategies should be used to promote it?

Instructional Strategies Used To Teach Critical Thinking

Sternberg (1990) does not specify a "how" approach to teaching and learning critical thinking skills. However, he provides general guidelines for developing or selecting a program/curriculum that will foster critical thinking. He recommends that instructors focus on strengthening students' intellectual functioning in meta-components, performance components, and knowledge-acquisition strategies. Meta-components refer to higher

order mental processes that require planning, monitoring, and evaluating individuals' actions. Performance components are the actual steps taken or strategies used, while knowledge-acquisition strategies refer to the ways that individuals relate old to new material and apply new material. Notably, Sternberg believes that the learning experiences provided during the formative school years are insufficient for learning how to solve problems and dealing with the critical thinking tasks that students will eventually face in everyday life. Exemplifying his point, he reports that the predominate use of tasks that demand right answers and truth telling as well as administering objectively scored tests, which is characteristic of formative education, do not contribute to the development of or require the use of critical thinking.

Like Sternberg, Lipman (1988) also does not specify a "how to" approach. However, he distinguishes between ordinary thinking and critical thinking. Ordinary thinking, such as guessing, believing, and supposing is simplistic because it does not rely upon the use of standards or criteria. Lipman describes critical thinking as a complex process that is self-correcting and based on standards of objectivity, utility, or consistency that requires students to reflect upon the certainty of their thinking. In other words, students must defend their thinking with evidence. To help students develop critical thinking skills, teachers need to understand the processes that constitute critical thinking and use instructional activities aimed at developing these processes. He recommends that teachers model how to: define and clarify information, ask appropriate questions, clarify or challenge statements or beliefs, judge the credibility of sources, and solve problems by predicting probable outcomes logically or through deducing. Ennis (1989) suggests that critical thinkers demonstrate particular attributes that distinguish them from others who do not demonstrate critical thinking. For example, they tend to: (1) be capable of taking a position or changing a position as evidence dictates, (2) remain relevant to the point, (3) seek information as well as precision in information, (4) be open-minded, (5) take into account the entire situation, (6) keep the original problem in mind, (7) search for reasons, (8) deal with the components of a complex problem in an orderly manner, (9) seek a clear statement of the problem, (10) look for options, (11) exhibit sensitivity to others' feelings and depth of knowledge, and (12) use credible sources. Critical thinkers generally use these skills without prompting.

CRITICAL THINKING TEST MEASURES

Cornell Critical Thinking Test (CCTT)

There are two forms of the Cornell Critical Thinking Test (CCTT), X and Z (Ennis, Millman, &Tomko, 2005). Form X is for students in grades 4-14. Form Z, is for advanced and gifted high school students, undergraduates, graduate students and adults. Form Z is a 52-item test that can be completed in 50 minutes. Reliability estimates for Form Z range from .49 to .87 across the 42 groups who have been tested for these purposes. Measures of validity were computed in *standard conditions*, roughly defined as conditions that do not adversely affect test performance. Correlations between Level Z and other measures of critical thinking range about .50. The CCTT was found to be predictive of graduate school grades. When the CCTT was correlated with the *Graduate Record Exam (GRE)*, a measure of aptitude and the *Miller Analogies Test*, scores were between .2 and .4.

Watson-Glaser Critical Thinking Appraisal-FS (WGCTA-FS)

Gazella, Hogan, Masten, Stacks, Stephens, and Zascavage (1999) reported that the WGCTA-FS, a 40-item inventory, replaced Forms A and B of the original test. According to Burbach, Matkin, and Fritz (2004), this inventory assesses test takers' skills in: (1) inference, the extent to which an individual determines the degrees of truth or falsity; (2) recognition of assumptions, whether the individual recognizes unstated assumptions or presuppositions in statements and assertions; (3) deduction, whether an individual decides if certain conclusions follow the information provided; (d) interpretation, whether an individual considers evidence provided and determines whether generalizations on data are warranted; and (e) evaluation of arguments, whether an individual distinguishes between strong and relevant arguments from weak and irrelevant within particular issues. Internal consistency and test-retest reliability for the WGCTA-FS is .81. Researchers investigated the reliability and validity of the WGCTA-FS for students in academic fields. The findings showed that internal consistencies for the total WGCTA-FS among students from 586 universities who were majoring in psychology, educational psychology, and special education including undergraduates and graduates ranged from .74 to .92. Gazella et al. (1999) report that the correlations between course grades and total WGCTA-FS scores for all groups ranged from .24 to .62. The WGCTA-FS was found to be a reliable and valid instrument for measuring critical thinking among this group of

participants.

California Critical Thinking Skills Test (CCTST)

The *California Critical Thinking Skills Test* predicts strength in critical thinking skills in authentic problem situations and success on professional licensure examinations. It also provides an objective measure of critical thinking skills. Items on Forms A and B parallel one another question for question and response for response. Thus the forms can be used when a split-half pretest posttest design is desirable and when testing groups of more than 100. Both forms are suitable for college level and post-baccalaureate student populations. Questions provide opportunities for test-takers to: (1) analyze or to interpret information, (2) draw accurate and warranted inferences, (3) evaluate inferences and explain why they represent strong or weak reasoning, and (4) explain why a given evaluation of an inference is strong or weak. All the questions are text-based. Both forms contain 34 multiple-choice items of varying levels of difficulty and can be administered in a 50-minute period. The tests is comprised by five subscale scores including Analysis, Evaluation, Inference, Deductive Reasoning, and Inductive Reasoning and a total critical thinking skills score. The total score is considered to be a valuable predictor of success in workplace contexts and for the successful completion of educational programs, certification, and licensure examinations. Significant relationships between CCTST and other measures including the GRE total, GRE-analytic, GRE-Verbal, GRE-Quantitative, the WGCTA, and the SAT Math and Verbal have been reported. Depending on the testing context, KR-20 alphas range from .70- .75. The newest version is CCTST Form 2000. Depending on the testing context, KR-20 alphas range from .78-.84 (Facione, Facione, & Giancarlo, 2000). Previous studies showed that the California Critical Thinking Skills Test captured gain scores in students' critical thinking over one quarter or one semester. Multiple health science programs have demonstrated significant gains in students' critical thinking using site-specific curriculum (Facione et al., 2000). Studies conducted to control for re-test bias showed no testing effect from pre- to post-test means using two independent groups of critical thinking students. Since participant's desire to answer in ways that would please the researcher -- social-desirability bias-- can influence responses on behavioral science measures, the researchers urge participants to take the Marlowe Crowne Social Desirability Scale simultaneously when measuring pre- and post-test changes in critical thinking skills.

OBJECTIVES OF THIS REVIEW

The primary objective of this study was to review and summarize recent studies in which critical thinking skills were measured using published protocols, namely, the Cornell Critical Thinking Test (CCTT), the Watson-Glaser Critical Thinking Appraisal (WGCTA), and the California Critical Thinking Skills Test (CCTST). The presentation is organized by overviews related to instructional intervention, test measure, and research design**.** Three related objectives of the study were to summarize if critical thinking skill changes occurred more frequently: (1) due to a particular instructional approach such as a course intervention or an immersion of critical thinking skills, (2) when a particular test measurement was used, and (3) due to the use of certain research designs. A subsequent meta-analysis will explore the differences among these studies and selected explanatory variables.

CRITERIA FOR SELECTING STUDIES

The authors conducted an extensive literature search to identify studies for this review. The time frame of the search was 1994 to 2009. Search results were limited to empirical studies that focused on promoting college students' critical thinking skills through instructional intervention and assessed changes in students' critical thinking using one of the three critical thinking skills measures cited above. Studies selected include research articles in peer-reviewed journals, published conference papers, and dissertations.

The databases searched included: ERIC (Educational Resources Information Center), SSCI (Social Sciences Citation Index), ProQuest Dissertation and Theses, EBSCO Professional Development Collection, PsycInfo, EBSCO Psychology and Behavioral Sciences Collection, EBSCO Mental Measurements Yearbook, WilsonWeb Education Full Text, WilsonWeb, OmniFile Full Text Mega, WilsonWeb Social Sciences Full Text, ABI/Inform Global on ProQuest, OCLC PAIS International EBSCO EconLit, EBSCO Academic Search Premier, CSA Social Services Abstracts, CSA Sociological Abstracts, PubMed, and Francis. The keywords used for the search included: critical thinking, WGCTA, CCTT, CCTST, pretest, posttest, college, higher education, and university. This search resulted in 61 studies.

These studies were reviewed to decide if they met the inclusion criteria: (1) presence of an educational intervention; (2) presence of pretest and posttest scores; (3) quantitative data sufficiency, the provision of sufficient data so that the effect size could be calculated for a prospective study; and (4) usage of one or more of the three critical thinking instruments, i.e. WGCTA, CCTT, and CCTST. 42 studies met the inclusion criteria.

INSTRUCTIONAL INTERVENTION

Two types of instructional interventions are described in this review: programmatic, pertaining to the whole curriculum of a degree program, and instructional, pertaining to specific instructional approaches.

Programmatic Approach

Studies using this type of intervention tested the students' critical thinking at the beginning and the end of the degree program, or conducted a pretest and posttest over a period of usually no shorter than 12 months, and examined whether significant differences were present. In the sample utilized for this review, 19% (n= 8) of the studies investigated the change of students' critical thinking during degree programs. Of these studies, six showed statistically significant growth in students' critical thinking at the posttest. Bartlett and Cox (2002) tested 26 physical therapy students over a period of 12 months and found significant gains in all subscale scores and in the total score for CCTST. Scott, Markert, and Dunn (1998) used the WGCTA to determine changes among 68 medical students' critical thinking skills at entry and near the end of their third year. Significant increases in the total score were observed. The researchers attributed the gains to the medical education process. Magnussen, Ishida, and Itano (2000) recorded critical thinking data for 150 nursing students over 4 years in order to determine the effect of a newly adopted teaching method, the inquiry-based learning (IBL). Their finding showed that students with different pretest scores change differently during the course of their program. Those with the lower pretest scores showed significant gain at the posttest, while students with the higher pretest scores demonstrated a significant decline at the posttest. The researchers suggested that students with lower pretest scores benefitted more from IBL than those with higher pretest scores, or that the results demonstrated regression to the mean.

Since programmatic intervention involves a longer period of time, there are particular threats to the internal validity of the instrument such as maturation and mortality. Although a larger number of studies on the effect of curriculum found significant growth in students' critical thinking, few of them exercised sufficient efforts to address these threats. The majority of studies in this category adopted a pre-experimental design. Because this design lacks a control group, causal effects due to the curriculum on students' critical thinking cannot be established. "Generally speaking, research reveals more years of education is associated with higher scores on tests for critical thinking" (Tsui, 1998, p. 8). The studies in this review did not discuss how factors related to college education beyond the curriculum, i.e., out-of-class experiences could have influenced changes in students' critical thinking. Thompson and Rebeschi (1999) tested 38 nursing students over a period of 18 months and found a significant increase in critical thinking. Although they acknowledged that extraneous variables such as maturation and significant life transitions may have affected the development of students' critical thinking, they did not state whether it was the curriculum or extraneous variables that caused significant differences. Similarly, Phillips, Chesnut, and Rospond (2004) observed statistically significant improvement in pharmacy students' critical thinking over a four-year period. However, they acknowledged that the lack of a true experimental design did not allow them to determine the potential causes for the observed changes. In other words, change in students' critical thinking was detected but not explained. Many of the studies reported change in students' critical thinking, but they were unable to determine factors that have led to such change, or to establish causality.

Instructional Approaches

In this review, we adopted Ennis' (1989) typology of instructional approaches. According to this typology, "critical thinking can be taught 'separately' (the "general" approach), be infused in instruction in existing subject-matter areas (the "infusion" approach), result from a student's immersion in the subject matter (the "immersion" approach), or … be taught as a combination of the general approach with infusion or immersion" (Ennis, 1989, p. 4). The general approach aims to teach critical thinking abilities and dispositions and it does not involve subject matter.

The infusion approach and the immersion approach, on the other hand, try to teach critical thinking skills when teaching subject matter. What distinguishes the infusion and the immersion approach is that the former makes it explicit that the principles of critical thinking are being taught while in the latter they are not. In other words, students taught with the immersion approach are not aware of that they are being trained to think critically.

A large proportion (52%, n = 22) of the literature reviewed for this study applied the immersion approach (See Figure 1) , which yielded the lowest percentage of finding significant growth in critical thinking, compared with the three other approaches. This finding is consistent with Abrami, Bernard, Borokhovski, Wade, Surkes, Tamim, and Zhang's (2008) assertion that "improvement in students' critical thinking skills and dispositions cannot be a matter of implicit expectation" (p. 1121).

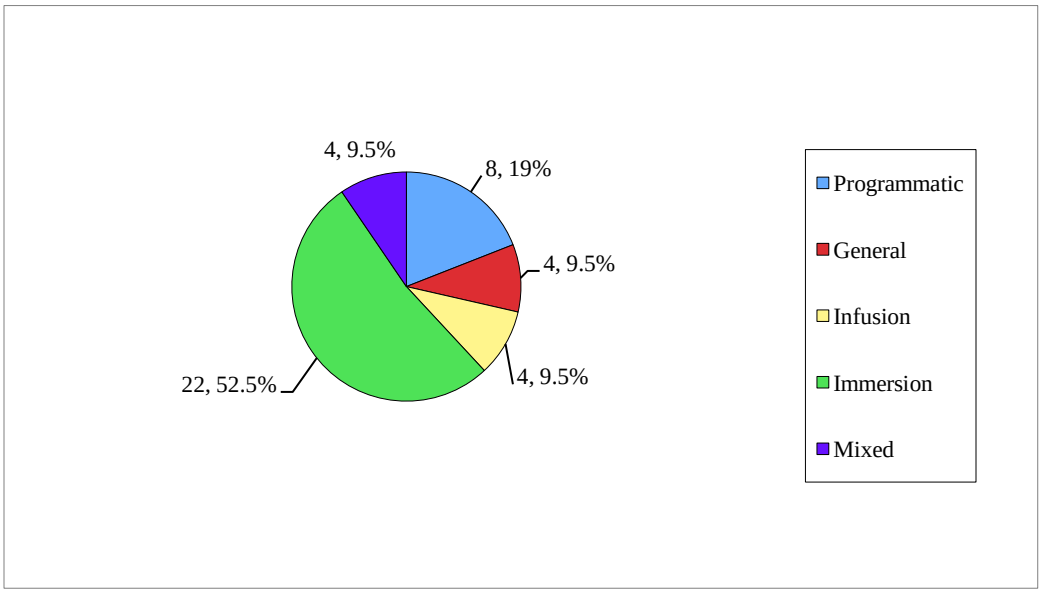

Figure 1: Instructional Approach, Number and Percentage, n=42

The specific instructional methods investigated included concept mapping (Boyadjian-Samawi, 2006; Wheeler & Collins, 2003), scenario-based course exercises (Sandor, Clark, Campbell, Rains, & Cascio, 1998), active learning techniques (Burbach, Matkin, & Fritz, 2004; Teixeira, 2001; English, 1998; Gelven, 1997; Goodin, 2005), problem based learning (Sendag & Odabasi, 2009; Hesterberg, 2005; Weissinger, 2003; Yuan, Kunaviktikul, Klunklin, & Williams, 2008), inquiry based learning (Magnussen, Ishida, & Itan, 2000), question approach (Thompson, 2009), guided practice (Coker, 2009; Lierman, 1997), computer-assisted instruction (Erickson, 1999; Daud, & Husin, 2004; Yang, 2008), structured web-based bulletin boards (Yang, Newby, & Bill, 2008), and online instruction (Yang, & Chou, 2008). The results were mixed; no single instructional method was shown to be either always effective or ineffective.

Two studies examined the effect of concept mapping on baccalaureate-nursing students' critical thinking skills over a period of 15 to 16 weeks and assessed changes using CCTST (Boyadjian-Samawi, 2006; Wheeler & Collins, 2003). While the former did not show statistically significant increases in students' critical thinking skills, the latter detected significant growth for students in the experimental group on the posttest. In an effort to explain the absence of statistically significant differences, Boyadjian-Samawi argued that the research design, the curriculum, students' learning processes, and length of study could have influenced the results of the study (p. 124). Wheeler and Collins concluded that concept mapping was effective in promoting students' critical thinking, and added that the research design and instrument might have affected their ability to detect differences between the experimental and the control group.

Sendag and Odabasi (2009) did not find statistically significant differences on the posttest scores between the problem based learning group and the instructor-led group. They pointed out several factors that might have influenced the study results -- for example the performance measures used, the specific instructional method used for the control group, the age of the students, the duration of the intervention, the organization of the learning resources and the role that the instructor played in facilitating student learning. Although no statistically significant differences were found, the researchers reported that students experienced some positive changes in critical thinking. They concluded that despite a lack of detectably significant differences, problem based learning is effective in leading learners to engage in the process of higher order thinking and learning.

These findings suggest that different implementation (who the students are, how they are taught, how the critical thinking is measured) while using the same instructional approach could lead to different effects on students' critical thinking and influence the possibility of detecting critical thinking changes. Sometimes when statistical significance is not shown, researchers confirm the practical significance of the instructional approaches.

TEST MEASURE

From the studies reviewed, the Watson-Glaser Critical Thinking Appraisal (WGCTA, 45% of the studies reviewed, n=19) and the California Critical Thinking Skills Test (CCTST, 45% of the studies reviewed, n=19) were used more frequently than the Cornell Critical Thinking Tests (CCTT, 10% of the studies reviewed, n=4). While the WGCTA and the CCTST yield mixed results, all of the studies using the CCTT detected statistically significant differences on the posttest or between the experimental and the control groups. Since it is difficult to detect patterns in four studies, we cannot draw conclusions in comparing CCTT to WGCTA or CCTST.

The most commonly cited reason for using the aforementioned standardized tests was that they were widely used and that experts had established their reliability and validity. Yet, many authors did not explain why they selected one or more particular type(s) of test to measure students' critical thinking. Approximately 50% of the studies used one or more other test(s) to measure relevant variables, including students' subject content acquisition, learning styles, or study skills. These tests included self-appraisal (Plath, English, Connors & Beveridge, 1999), written journals (Lierman, 1997), content knowledge acquisition test (Sendag & Odabasi, 2009), discipline specific scales, e.g. the Self-Assessment of Clinical Reflection and Reasoning for occupational and physical therapy students (Coker, 2009), and researcher-developed measures (Hesterberg, 2005).

Plath et al. (1999) developed a self-appraisal to collect qualitative data from students regarding their perspective on how critical thinking is understood (p. 214). On the pretest and posttest appraisal students were asked to write about their own critical thinking skills, how they applied these skills and the effect of the treatment. The results showed that students identified a range of abilities that have been developed from the treatment. The results of this non-standardized test corroborated the finding of statistically significant growth observed on the standardized test. The use of self-appraisal also showed that some findings could not be detected by solely using standardized tests. For example, answers to the appraisal showed that the development of critical thinking skills often involves non-cognitive factors, such as self-esteem, open-mindedness, and personal values. These findings provide instructors and researchers with valuable supplementary information that complements quantitative test scores.

Lierman (1997) uses written journal to reveal students' definitions of their own critical thinking skills and their perceived changes in critical thinking during the instructional intervention. She used this approach to corroborate the findings obtained from the quantitative instruments. Some findings from responses to journal questions corroborated those of the standardized instruments, while others did not. Overall, the quantitative analysis did not reveal statistically significant differences between the treatment and control groups. However, participants' journal responses from both groups show that their awareness in applying critical thinking in practice had increased. Both groups reported improved critical thinking and their belief that the course had been a positive influence in their growth. The use of open-ended journal responses captured changes in students' critical thinking that were otherwise undetectable by standardized tests and highlighted the practical significance of the course. Coker (2009) used the Self-Assessment of Clinical Reflection and Reasoning (SACRR), a quantitative test designed for occupational and physical therapy students and clinicians, to test study participants' clinical reasoning skills. She combined the

SACRR with the CCTST to evaluate the effect of a one-week hands-on experiential learning program on occupational therapy students' critical thinking skills. Both instruments showed significant growth in students' clinical reasoning skills and critical thinking. The SACRR corroborated findings from the CCTST and revealed changes specifically related to occupational therapy.

Researchers also developed instruments to measure students' critical thinking. Terry (2007) developed the Claim and Evidence Assessment Tool (CEAT) to measure students' ability to identify claims and support their claims with evidence. The CEAT and the WGCTA showed that students realized improvement in general critical thinking skills and in their ability to identify claims and evidence. Both tests revealed no statistically significant differences between the treatment and control groups, though. The researcher-developed instrument supported the findings of the standardized test.

Other than the CCTT, WGCTA, and CCTST, most of the other instruments collected quantitative data. The most common format of those tests was multiple-choice. Only five studies used qualitative instruments to investigate the change in students' critical thinking (Plath, et. al., 1999; Lierman, 1997; McGregor, 2001; Yuan et al., 2008; Yang, 2008). Researchers argued that critical thinking should be measured by multiple measurements instead of relying solely on standardized tests. Spicer and Hanks (1995) emphasized that critical thinking is a composite of general and specific factors that are better measured by both multiple-choice tests and open-ended measurements such as interviews. Sormunen and Chalupa (1994) concurred, pointing out that both quantifiable and qualitative methods should be used. They also argued that how responses to open-ended questions are evaluated is the key to supporting or refuting findings from the quantitative instruments. Moreover, more emphasis should be placed on justifying students' response instead of only looking at the response itself. Brunt (2005b) recommended using observation to capture the context of the subject matter. Otherwise, the qualitative aspects may be missed. She emphasized the importance of depicting not only what students think but also how they think. Her use of open-ended methods demonstrated that they could be more sensitive in showing how students reach their decisions when exposed to situations that require critical thinking skills. Differences between the quantitative and qualitative analysis were shown in Lierman's (1997) research, illustrating how qualitative data can inform researchers about the effect of instructional interventions.

RESEARCH DESIGN

Experimental Designs

According to Campbell and Stanley's (1963) research design typology, three research design categories are designated: the pre-experimental design, the quasi-experimental design, and the true experimental design. Pre-experimental designs include the one-shot case study, the one-group pretest-posttest design, and the static-group comparison. Quasi-experimental designs include the time-series experiment and the nonequivalent control group design among others. True experimental designs include the pretest-posttest control group design, the Solomon four-group design, and the posttest-only control group design.

Pre-experimental designs lack control group and random assignment, and are the most vulnerable to threats to internal validity. This type of design is the least powerful. Quasi-experimental designs usually lack random assignment and are also vulnerable to certain threats to internal validity, such as group-related threats. True experimental designs involve "two or more differently treated groups and random assignment to these groups" (Dooley, 2001, p. 165). This design type can control for both time-related and group-related threats and is the most powerful design.

Of the studies for this review, only three (7%) adopted a true experimental design. A large portion of the studies (33%, n=14) used the pre-experimental design, while the majority of the studies (60%, n=25) adopted the quasi-experimental design, as shown in Figure 2. Most studies using the quasi-experimental design adopted treatment/control group pretest-posttest to determine whether the instructional intervention helps students develop critical thinking. However, this design lacks random assignment and cannot control for group-related threats.

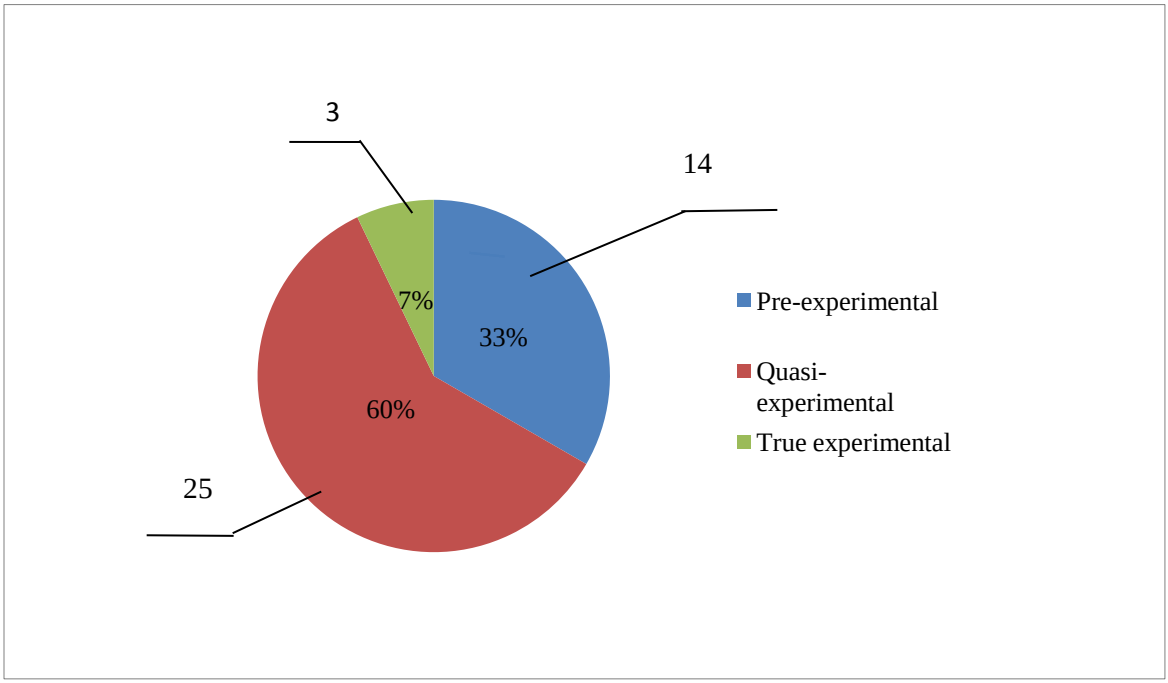

Figure 2: Research Design, Number and Percentage, n=42

Yang and Chou (2008) adopted the quasi-experimental design, and pointed out that their use of a purposeful sample was a study limitation. They cautioned that future studies should include the use of random assignment and sample participants from a diverse demographic sample. From the studies reviewed, many researchers who have adopted quasi-experimental designs did not mention the limitations of their research design. Instead they drew conclusions without addressing threats to the validity. The researchers' failure to acknowledge research design limitations suggests that they may not have considered this facet to be crucial in justifying their conclusions.

The random selection and assignment of participants in empirical research has implications for making claims that statistical differences are attributable to the treatment. In many of the studies reviewed, the researchers and instructors did not have control over the enrollment of students in courses, thus participants were convenience samples. As discussed in the Instructional Intervention portion of this review, researchers should be cautious in drawing causal conclusions when they cannot adopt a true experimental design. They should also address the limitations of experimental design by using statistical methods to control for possible differences between the treatment and the control groups such as selection bias.

For studies that only used one group, it was difficult to assert a causal relationship between the treatment and change in critical thinking unless the threats to the validity were properly addressed. The most commonly used pre-experimental design in the studies in this review was the one-group pretest-posttest design. Campbell and Stanley (1963) refer to this design as "worth doing where nothing better can be done" (p. 7). Several confounded extraneous variables such as history, maturation, and testing could jeopardize the internal validity of the test. Allegretti and Frederick (1995) used a pre-experimental design and concluded that a model of critical thinking applied to a group of 24 senior-level students was effective in promoting students' critical thinking. They also suggest that the model should be applied to other courses. However, without a control group, recorded growth on critical thinking scores may not be the result of the treatment. Threats to internal validity such as maturation may have influenced the outcome. Thus, the veracity of their conclusion and the recommendations to apply their model to other courses should therefore not be taken at face value.

When looking at the proportion of statistical significance found in each experimental design category, it is clear that the pre-experimental design reveals statistically significant results at the posttest more frequently than the quasi and true experimental designs (as shown in Figure 3). The high proportion of statistical significance found among these studies was likely the result of variables confounded with the treatment, such as history, maturation, and testing, rather than a result of the treatment. When controlling for such variables, the chance of detecting changes in students' critical thinking skills is greatly reduced. All of the studies using true experimental design fail to find statistical significant change at the posttest. One implication of this finding is that researchers should try to at least adopt a quasi-experimental design. Otherwise, the value of their research would be jeopardized.

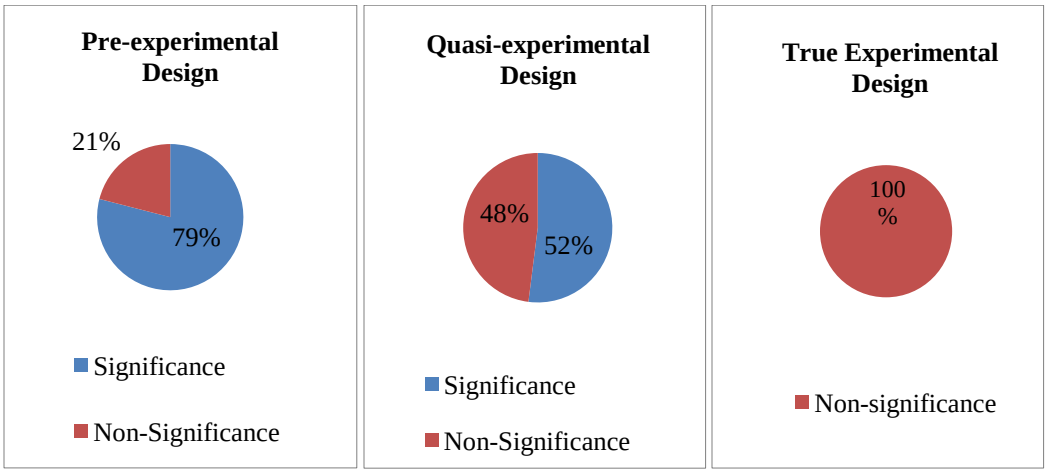

Figure 3: Proportion of Statistical Significance by Research Design

Other Limitations

Besides convenience samples, researchers cited small sample size and attrition as study limitations. Magnussen et al. (2000) and Boyadjian-Samawi (2006) failed to record statistically significant change in students' critical thinking. They argued that if larger sample sizes had been available, than their results might have been different. Hesterberg (2005), Goodin (2005), and Lierman (1997) pointed out that attrition weakened their studies. Spelic et al. (2001) stated that the small number of participants was a limitation of their study. Teixeria (2001) admitted that the sample size used in his study was too small to achieve the desired statistical power. Without a large enough sample size, it could be difficult for researchers to detect the possible effect of the instructional treatment that they are interested in. Researchers also reported concerns about the representativeness of the sample (n=17). Yet, sometimes they found it impossible to control the selection and assignment of sample because the study participants were volunteers and mortality was unavoidable. This issue is shared by many studies and warrants further attention when empirical studies on treatment effect are conducted.

Treatment Length

Another issue that influences the results of the studies is the duration of the treatment (see Figure 4). The length of treatment varied among the reviewed studies. Most treatment lasted for more than two months (79%, n=33). A larger part of the treatment (64%, n=27) lasted longer than four months, or one semester. Ten studies (24%) had treatment longer than nine months.

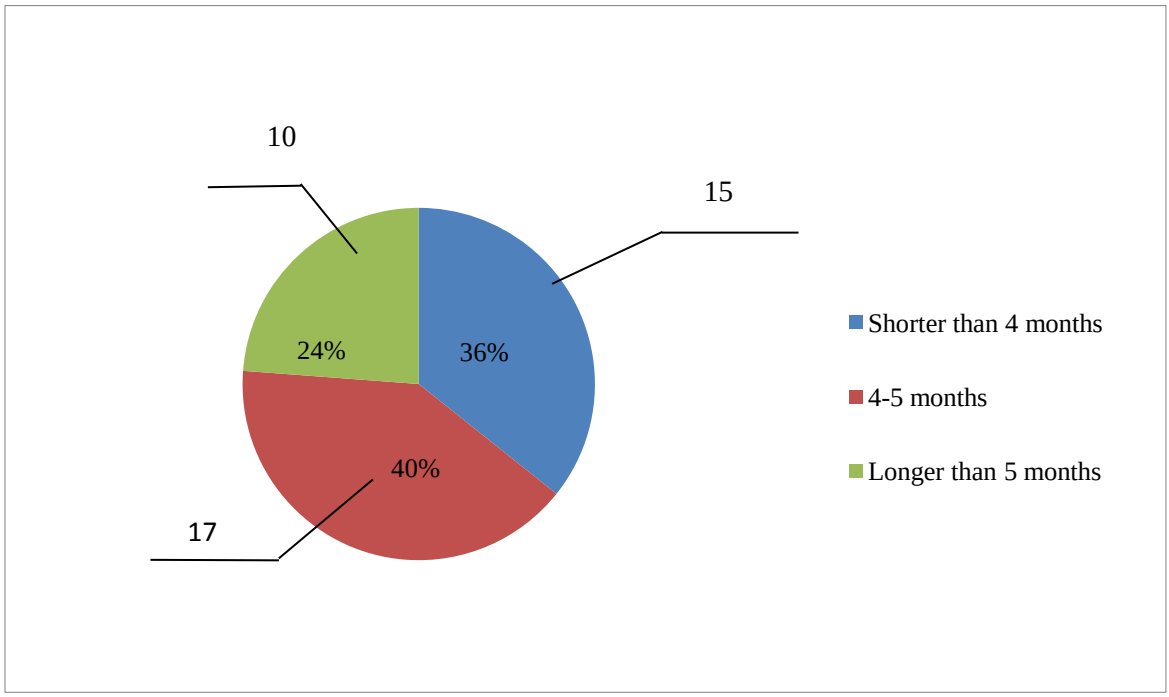

Figure 4: Treatment Length, n=42

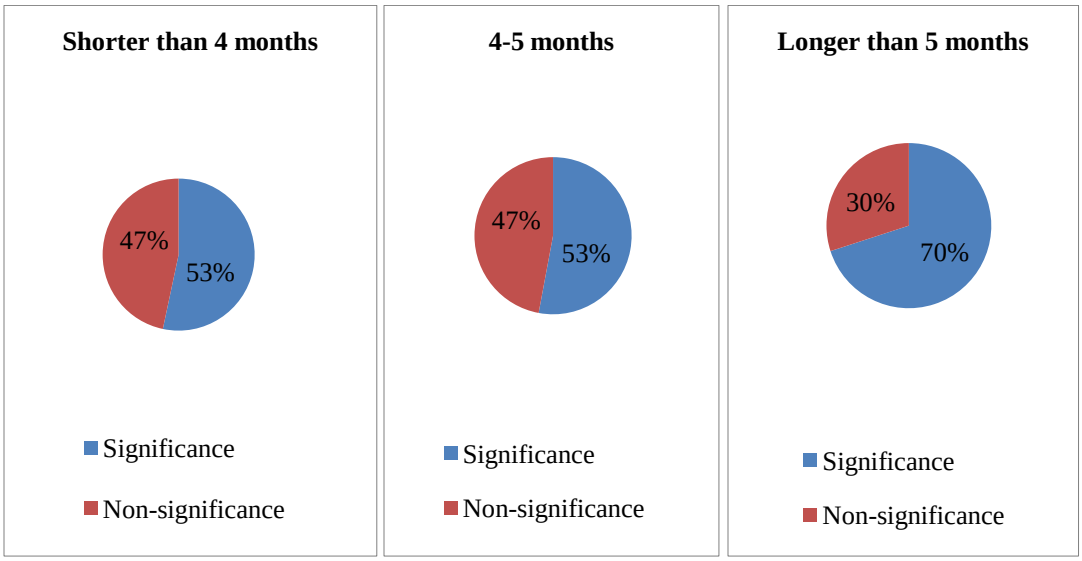

Figure 5: Proportion of Statistical Significance by Treatment Length

In Gelven's (1997) study, the four-month treatment failed to yield statistically significant changes in students' critical thinking scores. The researcher argued that critical thinking skills cannot be developed during a period of time as short as four months. Others including Teixeria (2001), Boyadjian-Samawi (2006), Lierman (1997), and Arburn (1999) noted that longer treatment was needed for significant change to be detected. They argued that treatment of one semester was not long enough and suggested longitudinal studies or follow-up studies that would be longer than four months. When looking at the results by treatment length, it is noteworthy that the proportion of studies finding statistically significant growth in students' critical thinking was higher with longer treatment, as shown in Figure 5. This pattern suggested that the longer the treatment, the greater the likelihood of

statistically significant changes in students' critical thinking. However, researchers should be cautious about controlling threats such as maturation, which become more apparent with longer period of time between pretest and posttest.

DISCUSSION

The objectives of the study were to summarize if critical thinking skill changes occurred more frequently:

(1) due to a particular instructional approach such as a course intervention or an immersion of critical thinking skills,
(2) when a particular test measurement was used, and
(3) due to the use of certain research designs.

With respect to course intervention or an immersion of critical thinking skills, we found that different implementations while using the same instructional approach led to different effects on students' critical thinking and influenced the possibility of detecting critical thinking change.

When examining a particular test measurement, the results showed that the WGCTA and the CCTST yield mixed results. Also all of the studies using the CCTT detected statistically significant differences. However, the results of the CCTT in comparison to WGCTA and CCTST were not representative because they constituted about 10% of the sample. More importantly, the findings suggested that the use of multiple measures could detect statistical or practical differences when quantitative measures cannot.

An exploration of the use of different research designs showed that pre-experimental designs were generally more likely to yield statistically significant results when compared to quasi- and true-experimental designs. It also showed that larger sample sizes and longer treatment lengths were more powerful.

In this review, we described how researchers studied the potential of improving undergraduate, graduate and professional students' critical thinking using varied instructional approaches. The review was limited to studies identified within a 15-year period that showed statistical results using the three most common quantitative measures of critical thinking. We identified patterns and commonalities among research outcomes with the hope that researchers will create more fine-tuned studies of critical thinking in varied instructional environments such as the classroom, clinic, laboratory, and studio, among others. We have reported the limitations of existing studies to encourage researchers to utilize more robust research designs.

Based upon the findings in this review, we point out several relevant concerns. Although studies may show significant findings, it is important to analyze the treatment implementation and research design as well as to ask if the results are justified given uncontrolled extraneous variables and research design limitations.

CONCLUSIONS

Concerns Related to Treatment/Interventions

Few studies provide detailed information about how the instruction is delivered. Yet, how and in what ways instruction is provided is crucial to facilitating changes in students' critical thinking. Knowing specifically how the instructor introduces and presents materials, facilitates learning, and uses formative and summative assessments of learning also provides a rationale for selecting the length of treatment/intervention. Apparent from the studies is that improvements in students' critical thinking are more likely to occur where the teaching of these skills is explicit rather than implicit. There are also extraneous factors such as the learning environment (resource-rich, resource-poor), the training that instructors receive, preparation and length of instructor experiences (or teacher effects), and the student-instructor and student-student interactions. To what degree these factors influence changes in critical thinking is unknown. Because of the lack of details provided, the reader might ask if it is the treatment itself that promotes change or if there are confounding unmeasured variables that produce it.

Future research should control potentially confounding factors that could influence observing statistically significant differences in students' critical thinking. Instructors who seek to promote students' critical thinking skills development should not rely solely on quantitative findings related to certain instructional approaches when deciding which teaching method to use, because sometimes changes in students behaviors cannot be detected using statistical measures. The lack of finding statistical significance does not necessarily indicate that the approach is ineffective.

Concerns about Test Measures

The studies reviewed demonstrate the importance of using more than one measure, particularly both quantitative and qualitative, to assess changes in students' critical thinking. Although standardized quantitative measures are relatively easy for researchers to use, their limitations, such as not being able to capture critical thinking changes within a specific context or discipline, should not be ignored. On the other hand, the advantages of qualitative measures should be better recognized. Therefore, when authors decide to use only one type of measure such as the standardized WGCTA and the CCTST, they should provide a rationale for why they think the single test measure is sufficient to capture students' critical thinking development. In addition, when researchers combine measures, they need to provide a justification for such combination. This would help researchers measure changes in critical thinking more comprehensively and accurately.

Future studies could use different measures to detect critical thinking development. On many occasions, resources to conduct research on college students' critical thinking were limited and warranted the use of multiple measurements. For example, small sample size and the lack of true experimental design often make it difficult for researchers to detect statistical significance. This, however, does not mean that no change occurs when treatments are applied. Using multiple instruments, including open-ended questions, essays, interviews, observations, and discipline-specific instruments developed by instructor or researcher can assist researchers in finding and describing the practical significance of treatments. In this way, the opportunity to identify factors that affect the development of critical thinking can be enhanced.

Researchers may use non-standardized tests less frequently because these tests require subjective scoring and it is difficult to establish reliability and validity. One example is Hesterberg (2005) in which the researcher creates the Standardized Client Assessment (SCA) to measure students' assessment skills. A measure of internal consistency, computed using a small pilot sample, was found to be acceptable. However, the researcher was not able to establish the validity of the measurement. Therefore, the data collected by this test were not analyzed and the hypothesis related to this measurement could not be tested. This example illustrates the risk of developing new instrument to measure critical thinking. Further studies are needed to address these challenges.

Concerns about Research Design and Method

The lack of proper control of treats to validity when using pre-experimental and quasi-experimental designs is an issue that warrants much attention. Results from a large number of studies on the effect of instructional intervention showed significant growth in students' critical thinking. However, the majority of these studies had adopted a pre-experimental design with no control group. Besides the treatment, variables such as maturation and significant life transitions may have influenced the development of students' critical thinking. Without controlling for threats to internal validity, it is difficult if not impossible to assert that there is causal effect of the investigated intervention on students' critical thinking.

While it is understandable that the nature of educational research (that researchers deal with people rather than objects or animals) as well as the limitation of available resources within higher education settings make it difficult or even impossible for researchers to adopt a true experimental design for studying changes in critical thinking skills among college students, we suggest that researchers enhance their research design and methodology. Shadish, Cook, and Campbell (2002) point out that "even the weakest quasi-experimental designs can be strengthened by adding thoughtfully chosen design elements that reduce the number and plausibility of internal validity threats" (p. 156). Such design elements include among others random assignment, matching and stratifying, posttest observations of nonequivalent dependent variables, repeated pretests over time, the use of cohorts, switching

replications, and repeated treatments (p. 157). Combined with pretest, the use of carefully selected control groups could facilitate causal inference from quasi-experimental designs. (p.136) We therefore recommend that researchers add certain elements to their quasi-experimental designs to address plausible internal validity threats.

From the studies in this review, we can see the trend that the longer the treatment, the greater the likelihood that there will be statistically significant growth in students' critical thinking. Thus critical thinking changes tend to be easier to detect with longer treatment. However, if researchers are to accept this suggestion, they should be cautious about controlling threats such as maturation and history, since their impact or influence can become stronger with longer period of time between pretest and posttest.

While pointing out the concerns described above, we ask readers to consider the trustworthiness of the publication and to critically analyze the substance of empirical studies on teaching critical thinking to college students. Peer reviewers may ignore the aforementioned challenges because of a lack in understanding about the topic or the research paradigm. In summary, we recommend that readers do not take what they read from empirical studies at face value without recognizing the aforementioned limitations.

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