

# Identifying Courses that Improve Students' Critical Thinking Skills Using the CAT Instrument: A Case Study

Kevin Harris, Barry Stein, Ada Haynes, Elizabeth Liscic, and Katie Leming  
Tennessee Technological University

**Abstract-** There is increasing interest in understanding how college education contributes to the development of critical thinking skills. The Critical thinking Assessment Test (CAT) initiated national dissemination in 2004 and has since been widely used by over 200 higher education institutions across the U.S. Many institutions are using the CAT instrument to evaluate college and program outcomes for accreditation and accountability purposes. This paper reports the results of using the CAT instrument to evaluate a collection of courses that specifically targeted the improvement of critical thinking skills in their learning objectives. The findings reveal that significant improvements in critical thinking can be obtained in a one semester course and that such improvements are not correlated with students' entering ACT scores. The authors suggest that this type of analysis can help institutions identify high impact practices that can be replicated and extended to create higher education experiences that have a greater impact on critical thinking.<sup>1</sup>

## INTRODUCTION

Critical thinking is often regarded as one of the most important components of higher education. For instance, the Higher Education Research Institute (HERI) found that over 99% of faculty across the United States felt that teaching critical thinking is "essential" or "very important" [1]. Accrediting agencies, such as Accreditation Board of Engineering and Technology (ABET), recognize the need for higher order thinking skills and real world problem solving in their accreditation standards [2]. Indeed, a recent survey by the American Association of Colleges and Universities (AAC&U) found that 75% of employers want colleges to place more emphasis on critical thinking, real world problem solving, communication, and creativity [3].

Despite general agreement on the importance of critical thinking, some researchers, such as Arum and Roksa, are questioning whether higher education is effective in helping students improve their critical thinking skills [4]. They note that at many colleges, students show little or no improvement in critical thinking when tested using the Collegiate Learning Assessment (CLA).

Tennessee Technological University (TTU) has been engaged in an extended effort during the last 10 years to help

institutions across the country evaluate and improve their students' critical thinking. The CAT (Critical thinking Assessment Test) instrument is an authentic assessment that uses short answer essay responses to assess critical thinking [5]. This strengthens the tool as student responses to this type of question provides a better understanding of students' thought processes and ability to think critically and creatively when confronted with real world problems [6]. In addition, the CAT instrument is unique in how it utilizes a campus's own faculty to evaluate student responses using a detailed scoring guide. The CAT instrument allows faculty to directly observe students' critical thinking and understand their students' deficiencies. This activity creates an opportunity to begin exploring modifications in teaching methods that might address these weaknesses. TTU and other institutions have found that the use of faculty scorers is an effective way to make faculty aware of student deficiencies in the area of critical thinking and to motivate faculty to consider changes in pedagogy that might improve students' critical thinking skills [7]. This becomes increasingly important as accrediting agencies, such as ABET, increase their focus on efforts to improve students' critical thinking [2].

Extensive testing and development has led to a test with high face validity, high construct validity, high reliability, and cultural fairness [8]. During the past 10 years, over 200 institutions ranging from community colleges to R1 research universities have used the CAT instrument to evaluate critical thinking and real-world problem solving skills. The majority of institutions using the CAT assess program level outcomes for accreditation and accountability purposes. These research designs generally assess students near graduation or students who have recently entered an institution or program together with students completing their programs of study. In many situations, institutions are attempting to determine the amount of impact a particular program has had on students' critical thinking skills.

Currently, there are over 33,000 student results in our national database. Figure 1 illustrates observed changes in student performance on the CAT instrument across class standing at four-year institutions. These results represent data collected across many different institutions. Although there was considerable variation in student age within our sample, the age of the student was found to have no significant relationship to test score once class standing was taken in to account. The latter results suggest that the gains reflected in student scores

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<sup>1</sup> Partial support for this work was provided by the National Science Foundation's TUES Program under grant 0717654. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

over the college experience are not merely the result of a maturation process independent of a college experience [9].

The results of our collaborations with over 200 institutions across the country indicate that higher education is contributing to gains in students' critical thinking. The data in figure 1 indicate an average increase of about 26% over a four year program of study. Should we expect greater gains? To answer the question about whether the college experience can and should produce greater gains in critical thinking as measured by the CAT instrument, it is necessary to evaluate the sensitivity of the instrument to the changes that might occur in a course/semester of study.

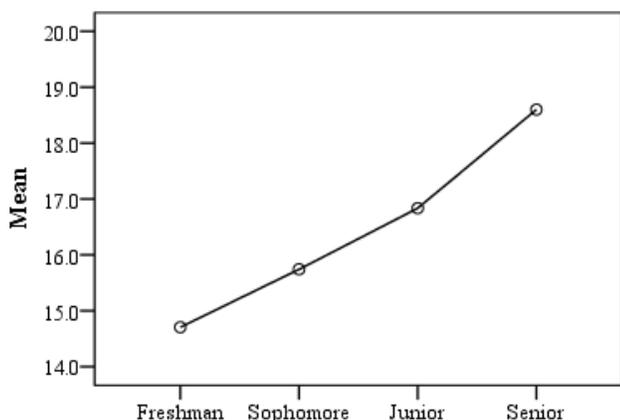


Fig. 1. Mean Scores on the CAT instrument at four-year Institutions by Class Standing.

To evaluate the sensitivity of the instrument to detect change it is useful to look at the gains that can be made in a single college course or semester. If sizable gains can be made in a single course/semester, then there is evidence that the instrument has sufficient sensitivity to detect change and we might begin to extrapolate what kind of improvement is possible for students across the entire college experience. This paper examines results from a variety of college courses that specifically tried to improve students' critical thinking skills within the context of learning a discipline's content.

#### METHOD

This study includes data collected as part of the Quality Enhancement Plan (QEP) at Tennessee Tech University. Seven courses in five departments (Business, Chemical Engineering, Civil Engineering, Psychology, and Sociology & Political Science) were designed to implement high impact teaching practices to engage students and improve critical thinking. All students enrolled in each course were tested at the beginning of the semester with the Critical thinking Assessment Test (CAT) and then again at the end of the semester. During the semester, faculty implemented varying types of high impact active learning activities designed to engage students in developing critical thinking and real-world problem solving skills. A random sample of 15 matched pairs of tests from each course was selected to be scored and included in the dataset. ACT scores were merged into the dataset from institutional

sources in order to provide a measure of academic ability. Not all students had an ACT score available.

#### Materials

The Critical thinking Assessment Test (CAT) was used as a pre and post measure of critical thinking in each course. The CAT instrument is designed to evaluate a broad range of critical thinking skills summarized in Table 1.

TABLE 1  
GENERAL SKILL AREAS ASSESSED BY THE CAT INSTRUMENT

<b>Evaluating Information</b>
Separate factual information from inferences.
Interpret numerical relationships in graphs.
Understand the limitations of correlational data.
Evaluate evidence and identify inappropriate conclusions.
<b>Creative Thinking</b>
Identify alternative interpretations for data or observations.
Identify new information that might support or contradict a hypothesis.
Explain how new information can change a problem.
<b>Learning and Problem Solving</b>
Separate relevant from irrelevant information.
Integrate information to solve problems.
Learn and apply new information.
Use mathematical skills to solve real-world problems.
<b>Communication</b>
Communicate ideas effectively.

#### RESULTS

The sample consisted of 8 freshmen, 18 sophomores, 48 juniors, and 31 seniors. There were 51 females, making up 48.6% of the sample. The average Pre CAT total score for the entire sample was ( $M = 17.50$ ,  $SD = 5.82$ ) and the average Post CAT total score was ( $M = 19.733$ ,  $SD = 6.04$ ). ACT scores were available for 98 students, and the average ACT score was ( $M = 23.57$ ,  $SD = 4.18$ ).

#### Courses Impacting CAT Total Score

One goal of the QEP at Tennessee Tech University was to improve students' critical thinking skills as measured by the CAT instrument. Students in two courses (Civil Engineering and Psychology) made significant gains on the overall CAT score using a paired sample t-test,  $t(14) = 3.116$ ,  $p < .01$ ,  $MSE = 5.22$ , and,  $t(14) = 6.410$ ,  $p < .001$ ,  $MSE = 5.65$ , respectively. Students in these two courses made gains of about 24% and 35%, respectively over the course of one semester. These courses produced gains in critical thinking skills equal to or greater than those observed across a 4-year education in our national database. One other course (Political Science) approached a significant difference,  $t(14) = 1.974$ ,  $p = .068$ ,  $MSE = 5.00$ .

#### Courses that impacted specific questions

Although only two of the seven courses evaluated significantly improved overall performance on the CAT instrument, two other courses improved performance on one or more skills assessed on the CAT instrument. Table 2 illustrates the number of courses that significantly improved performance on the

skills assessed by specific questions in the CAT instrument. All but two of the skill areas were impacted by one or more of the seven courses evaluated. It should be noted that three of the seven courses evaluated did not result in gains on any of the CAT questions.

TABLE 2  
SKILLS MEASURED BY INDIVIDUAL CAT QUESTIONS

CAT Question Focus	Courses Impacting
Summarize the pattern of results in a graph without making inappropriate inferences.	●
Evaluate how strongly correlational-type data supports a hypothesis.	●
Provide alternative explanations for a pattern of results that has many possible causes.	●●●
Identify additional information needed to evaluate a hypothesis.	●●
Evaluate whether spurious information strongly supports a hypothesis	●●
Determine whether an invited inference is supported by specific information.	●
Separate relevant from irrelevant information when solving a real-world problem	●
Use and apply relevant information to evaluate a problem.	●
Use basic mathematical skills to help solve a real-world problem.	●
Identify suitable solutions for a real-world problem using relevant information.	
Identify and explain the best solution for a real-world problem using relevant information.	
Explain how changes in a real-world problem situation might affect the solution.	●

#### Academic Ability and Improvement in Critical Thinking

Another goal of this project was to determine the impact of academic ability on student gains in critical thinking. Previous research on the CAT indicated that general academic ability as measured by the ACT and the SAT is moderately correlated with performance on the CAT [8]. The correlation between entering ACT scores and performance on the Pre and Post CAT scores in this study was also significant  $r(96) = +.573, p < .01$ , and  $r(96) = +.532, p < .01$ , respectively. These moderate correlations are similar to those found in previous work [10].

Using entering ACT scores to predict the improvement from the pretest to the posttest administration of the CAT revealed different results. Entering ACT scores were not significantly correlated with change in performance from the pretest to the posttest. Entering academic ability as measured by the ACT had no significant relationship to the improvement in students' critical thinking scores as measured by the CAT.

#### Gender and Improvement in Critical Thinking

It was also important to determine the impact of gender and whether or not gender differences accounted for any variation

in critical thinking improvement. The gender of the student was not significantly correlated with change in performance from the pretest to the posttest. Gender had no significant relationship to the improvement in students' critical thinking scores as measured by the CAT.

#### CONCLUSION

National norms for the CAT instrument suggest that four years of higher education may produce average gains of about 26% on the CAT instrument. While some have argued that higher education needs to do more to improve students' critical thinking, it has been unclear how much more progress is realistically possible.

This study evaluated seven courses, within specific disciplines, designed to improve critical thinking. Four of the seven courses positively impacted one or more of the skills assessed by the CAT. Of the skills assessed by the CAT instrument, all but two were positively impacted by at least one of those four courses. The gains experienced by students in these seven courses ranged from little or no gain to a gain larger in magnitude than that observed for a four year college experience. Taken together, these results suggest that we might expect to make considerably more progress in improving students' critical thinking if the effects of successful high impact courses can be replicated across multiple courses and disciplines and are additive across a college experience. Given the preceding assumptions are correct, we would expect to see greater improvements in students' critical thinking skills across a four year college experience.

The findings also suggest that gains in critical thinking are not related to entering academic ability as measured by ACT scores even though pretest scores on the CAT instrument are related to entering academic ability. The latter findings suggest that gains in critical thinking are not restricted to high performing or low performing students.

Gains in critical thinking were also not related to gender. Taken together, the findings related to the effects of entering academic ability and gender suggest that critical thinking improvements can be observed in a wide variety of students.

The results of this case study demonstrate that the CAT instrument can be effectively used to evaluate gains in critical thinking in individual courses. The latter approach may help institutions and researchers identify high impact practices that are helping students make substantial gains in critical thinking. By identifying the activities and pedagogies that lead to a significant improvement in critical thinking, institutions can make more informed curricular and course changes to increase the magnitude of critical thinking gains in their courses and programs of study.

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