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ABSTRACT

Correlations between the California Critical Thinking Skills Test--College Level (CCTST) and student-related factors regarded as indicators of academic ability and success were studied in a series of four experiments investigating whether the CCTST measures improvement in critical thinking (CT) skills. During 1989-90, data were collected on 1,196 college students at California State University (Fullerton), some of whom were enrolled in courses specifically designed to improve CT skills. Instructor-related factors were also evaluated for their impact on CT skill development. Regression models were developed for predicting CCTST results. Relationships between reading ability and native English language ability and the CCTST were also examined. CT skills could be predicted by a combination of verbal Scholastic Aptitude Test (SAT) score, mathematics SAT score, and grade point average. CCTST results correlated positively with reading test scores for vocabulary, comprehension, and total score. Non-native English speakers showed virtually no gains in CT skills from pretest to posttest. Only instructor years of teaching experience and recent experience teaching CT skills were related to CCTST results. No evidence was found to suggest that improvement in CT skills is a natural outgrowth of baccalaureate education; skills improvement did result from courses targeting such skills. Twelve tables provide study data. (SLD)

The California Critical Thinking Skills Test -- College Level

Technical Report #2

Factors Predictive of CT Skills

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The California Critical Thinking Skills Test: College Level

Technical Report #2 -- Factors Predictive of CT Skills

by

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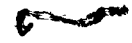
Abstract

Technical Report #2 builds on Technical Report #1 which discussed the content validity and the four experiments used to determine that the California Critical Thinking Skills Test: College Level (CCTST) measures improvements in the core CT skills of interpretation, analysis, evaluation, inference and explanation. During 1989/90, data was collected on a variety of variables related to the 1196 subjects who participated in these experiments. Critical thinking skills, as measured on the CCTST, can be predicted by a combination of SAT verbal, SAT math, and GPA data with R-square =.41 If CCTST pretest data are included in the regression model the R-square =.71. The college student's age, units of college work completed, and high school subject matter preparation, and the instructor's teaching experience contribute nothing of significance to the regression models which predicts CCTST posttest results. CCTST results positively correlated with Nelson-Denny reading scores for vocabulary, comprehension, and total score. Non-native English speakers show virtually no gain from pretest to posttest and, hence, use of the CCTST for this group of students is strongly counter-indicated. Of six instructor-factors which are thought to be related to effectiveness in teaching CT skills, only years of teaching experience and recent experience teaching CT are related, and these in non-linear ways. Applying the CCTST to the hypothesis that CT skill development is a natural outcome of baccalaureate education, no evidence for that hypothesis, either in general, or by reference to the control groups, could be discovered. This result is not viewed negatively. Not all professors should be expected to teach all skills. Technical Report #3 discusses student-related factors such as academic major, CT self-esteem, gender, and ethnicity. Technical Report #4 provides group norms and discusses CCTST sub-scores on analysis, evaluation, inference, deductive reasoning and inductive reasoning skills.

The California Critical Thinking Skills Test: College Level
Technical Report #2 -- Factors Predictive of CT Skills



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Recap of Previous Findings

Technical Report #1 discussed the content validity and the experimental validation of the California Critical Thinking Skills Test: College Level (CCTST). Those experiments were conducted in 1989/90 at California State University, Fullerton using 1169 undergraduate students enrolled in lower division general education requirements. From these experiments it was inferred that the CCTST succeeds in measuring the gains in CT skills which result from the completion of courses specifically designed and approved for CT development. No gain in CT skills was evident in either of the two control group experiments conducted during the same academic year at the university (Facione 1990 c). The CCTST addresses the core CT skills of interpretation, analysis, evaluation, inference and explanation and provides sub-scores on these three skills as well as deductive reasoning and inductive reasoning. During the 1989/90 research, data was also collected

on a variety of variables relating to the 1196 students and the 20 instructors who participated in these experiments. These data were gathered on participants in the two posttest administrations, Nov. '89 and May '90, and in the pretest administration of Feb. '90.

Technical Report # 2 discusses the correlations between the CCTST and several student-related factors generally regarded as indicators of academic ability and success. It also examines seven instructor-related factors for evidence of their impact on CT skill development. This report develops regression models for predicting CCTST results. It then examines the relationship between reading ability and native English language ability to the CCTST. This report challenges the hypothesis that college teachers generally promote CT skill development as a natural result of the educational experience.

Concurrent Validity of the CCTST

Among the student-related data gathered in 1989/90 was information on students' high school GPA, SAT-verbal and SAT-math scores. Statistical information available through the campus Admissions and Records Office also included data on the number of semesters of high school preparatory English, math, foreign language, and science taken prior to enrolling at the university. College GPA and the number of college units earned, as well as score on the California State University's English Placement Test and Entry Level Math Test were also made available through the university. The students themselves supplied only limited information, such as their age in years. They were also asked to respond to certain attitudinal and self-perception questions which are discussed in Technical Report #3.

So as not to contaminate these comparisons with the results of CT instruction, only the February 1990 pretest data was used to determine if interesting correlations existed between CT skills and other important indicators or predictors of academic achievement and success. Table 1 reports these findings.

CCTST pretest results are significantly correlated with seven factors including college GPA ($r=.20$, $p<.000$) and Scholastic Aptitude Test (SAT) Verbal Score ($r=.55$, $p<.000$) and the SAT Math Score ($r=.44$, $p<.000$). Students entering the California State University system with an SAT-verbal score below 470 must take the University's English Placement Test (EPT). Likewise, those with an SAT-math score below 530 must take the University's Entry Level Mathematics Test (ELM). As would be expected, the means for these measures, as reported on Table 1, fall below the means for the entire sample. The CCTST pretest scores were correlated with the EPT ($r=.48$, $p<.000$) and the ELM ($r=.13$, $p=.025$). Statistically significant correlations were also found between students' pretest CCTST scores and the number of semesters of high school preparatory English ($r=.16$, $P=.002$) and the number of semesters of high school preparatory Math ($r=.10$, $p=.039$). High school science and foreign language preparation were not statistically significantly correlated, however.

It is a widely accepted that mastery of CT skills increases as college students advance through their baccalaureate education. If, for example, the cumulative effect of a college education were generally to enhance students' critical thinking skills, then one might predict a positive correlation between the number of units of college work completed and growth in CT ability. However the results of these comparisons were surprisingly negative. Pretest CCTST scores were not significantly correlated with either age or college units earned. This result is disconcerting for those who hold the view that growth in CT ability is a "natural byproduct" of either a college education or the

maturation which occurs in young adulthood. On the other hand, these findings are most encouraging to those who hold that specific attention to the development of CT skills will occur only if this becomes a specific course goal, a planned outcome in curricular design, and a factor considered in the selection of instructional materials and pedagogical strategy.

Table 1

Feb. 1990 Pretest Correlations -- Concurrent Validity

Measure	rho	Sig.	Cases	Mean	Pretest
SAT-Verb	+.55	*p<.000	333	419	16.40
EPT	+.48	*p<.000	229	147	15.27
SAT-Math	+.44	*p<.000	333	477	16.40
ELM	+.13	*p=.025	218	51.1	15.22
GPA	+.20	*p<.000	473	2.66	16.11
Prep-Eng	+.16	*p=.002	314	7.7	16.47
Prep-Math	+.10	*p=.039	315	6.3	16.44
Prep-Sci	+.11	p=.081	155	3.8	16.23
Prep-Flng	+.01	p=.491	281	2.0	15.56
Units	+.03	p=.262	473	66.8	16.11
AGE	-.006	p=.449	479	22.03	16.10

While Table 1 shows seven significant correlations ($p < .05$) which obtain at the start of CT instruction, questions arise as to whether these correlations persist through to the culmination of one semester of CT study. On the Nov. '89 posttest data, six of the same seven factors were statistically significantly correlated with the CCTST posttest score. These are SAT-verbal, SAT-math, EPT, ELM, GPA, and semesters of college preparatory English. But the number of semesters of college preparatory math, which was significantly correlated with the pretest score, was not correlated with the posttest score at a statistically significant level. As Table 2 indicates, on the Nov. '89 posttest, age, number of college units completed again showed themselves not be correlated significantly with one's CT ability as measured by the CCTST.

Table 2

Nov. 1989 Posttest Correlations -- Concurrent Validity

Measure	rho	Sig.	Cases	Mean	Posttest
SAT-Verb	+.62	*p<.000	275	415	16.87
EPT	+.57	*p<.000	206	148	15.89
SAT-Math	+.48	*p<.000	275	494	16.87
ELM	+.24	*p<.000	188	52.8	15.96
GPA	+.22	*p<.000	404	2.75	16.81
Prep-Eng	+.19	*p=.001	269	7.8	16.87
Prep-Math	+.10	p=.054	269	6.5	16.87
Prep-Sci	+.08	p=.231	231	4.1	16.67
Prep-Flng	-.02	p=.355	248	1.4	16.67
Units	+.06	p=.124	404	76.1	16.81
AGE	+.01	p=.403	461	22.9	16.85

However, as Table 3 indicates, all seven significant correlations discovered to apply to the Feb. 1990 pretest were found to be significant on the May 1990 posttest: SAT-verbal, EPT, SAT-math, ELM, GPA, semesters of college preparatory English and mathematics in high school.[1]

Table 3

May 1990 Posttest Correlations -- Concurrent Validity

Measure	rho	Sig.	Cases	Mean	Posttest
SAT-Verb	+.55	*p<.001	193	420	17.43
EPT	+.38	*p<.001	127	146	15.79
SAT-Math	+.47	*p<.001	193	479	17.43
ELM	+.20	*p<.014	122	52.1	15.98
GPA	+.29	*p<.001	260	2.72	17.39
Prep-Eng	+.13	*p=.040	184	7.8	17.42
Prep-Math	+.14	*p=.025	184	6.4	17.42
Prep-Sci	+.08	p=.230	96	3.9	16.93
Prep-Flng	+.13	p=.057	146	1.7	16.99
Units	+.08	p=.106	260	65.3	17.39
AGE	+.01	p=.444	262	21.7	17.39

Predictors of CT Skills

Individually the student-related factors found to be statistically significant included seven already mentioned and certain others: CT self-confidence, English language ability,

and the academic major in which the student hopes to graduate, the perception of the relationship of one's CT ability and GPA, ethnicity/race, and, in one analysis, gender.[3] But, just as body weight can be correlated positively with reading ability in elementary school children, one must be cautious about how any of these findings about individual factors, considered in isolation, is interpreted. Human performance is the result of the complex interaction of many factors, not the result of any one factor taken by itself. Any single factor, even where a strong correlation is discovered, may turn out to be unimportant when considered in combination with other factors. Discovering that combination of factors which, taken together, best predicts a student's CT skill is crucial to optimal CT instruction and to the utility of CT assessment tools, such as CCTST.

Several stepwise multiple regression analyses were conducted in order to build a model of that combination of factors which best and most economically predict CCTST results. The data from the May '90 posttest and the Nov. '89 posttest were combined so as to maximize the number of cases for the regression analyses. Certain factors, because of the nature of the way they were measured, could not be entered into the regression equations. Using the backward method variables initially introduced into the regression equation were taken out, one by one, as it became evident that their continued presence contributed nothing significant to the equations ability to predict variances in the dependent variable -- the CCTST posttest score.

One regression analysis of interest produced a Multiple-R of .84100 and an R-square of .70729. ($F = 239.83$, df 4, 397, Sig. of $F = .0000$). This analysis indicates that roughly 71% of the variance in the posttest scores could be predicted by the combination of four factors which remained in the equation after the backward analysis was completed. In this model nine independent variables were entered into the initial regression equation in this order: Pretest score, age, preparatory Math, preparatory English, college GPA,

high school GPA, SAT verbal score, SAT math score, and number of college units completed at the start of the semester. However, EPT and ELM scores were omitted because of their SAT score interdependence. Table 4 indicates the combination of four factors which remained in the equation, the Beta weights suggest the relative importance as individual predictors on the condition that these four factors are the ones being considered.

Table 4

Predictors of CT Skills as Measured on the CCTST with Pretest

Factor	Beta Weighting
Pretest Score	.70041
SAT Verbal Score	.13407
SAT Math Score	.08222
College GPA	.05449

The CCTST pretest score is such a strong factor in the previous model that the relative strength of various other factors might change sharply if no CCTST pretest data is available. A model using the eight other factors was examined. In the following order these eight factors were entered into the initial equation: high school preparatory Math, college units earned at the start of the semester, SAT verbal score, preparatory English, high school GPA, SAT math score, college GPA and age. The Multiple-R which resulted was .64001; R-square was .40961 (F = 68.85825, df 4, 397, Sig. of F = .0000). This indicates that roughly 41% of the variance in CCTST posttest scores can be accounted for using those four factors which remained in the equation after the backward analysis reached its limits. Table 5 indicates the remaining factors and their relative Beta weights.

Table 5

Predictors of CT Skills as Measured on the CCTST

Factor	Beta Weighting
SAT Verbal Score	.44116
SAT Math Score	.28245
College GPA	.13245
High School GPA	- .09316

Effectiveness of Particular Courses

Posttest data were gathered from sections of approved CT courses offered by three departments: Philosophy, Psychology and Reading. In all, seventeen different faculty persons were involved as instructors in the various sections of the four courses used in this research. The four one-semester lower division general education courses, by title, were Philosophy 200 *Logic*, Philosophy 210 *Argument and Reasoning*, Psychology 110 *Reasoning and Problem Solving*, and Reading 290 *Critical Reading as Critical Thinking*.[2] Table 6 shows the mean scores by course number for the Nov. '89 posttest and the May '90 posttest.

Table 6

Course	Nov. Mean	Std Dev.	n.	May Mean	Std. Dev.	n.
Psychology 110	16.43	3.95	86	16.00	4.73	38
Philosophy 200	16.79	4.57	194	17.64	5.28	31
Philosophy 210	16.95	5.46	141	17.32	4.51	116
Reading 290	17.45	3.72	44	18.08	4.26	77

These differences by course were not statistically significant, but they did suggest tendencies. Particularly, note that the Reading mean scores surpassed the others in both posttest groups. Also in both groups the standard deviation for the scores of the reading students' were the smallest. As a result, an analysis was done combining Nov. '89 and May '90 data and grouped only by sponsoring Department. Table 7 indicates that there was a statistically significant difference among the scores obtained by the three departments, (F = 3.4408, df 2, 723, Sig of F = .0326, Eta Sq. = .0094).

Table 7

Department	Combined Posttest Mean	Std Dev.	Cases
Reading	17.8512	4.0675	121
Philosophy	17.0187	4.8753	481
Psychology	16.2984	4.1886	124

While such differences are remarkable in that they tend to counter some of the presumptions sometimes found in the academy, pending a fuller study of the instructor-related variables discussed below, these findings should be interpreted with caution. Significant CT development can occur by virtue of instruction from any of the three departments. The Eta-square suggests that less than 1% of the variance is attributable to this factor. Thus, the critical comparison for student assessment purposes must remain that which contrasts outcomes from CT courses with outcomes from course not specifically designed to foster the development of CT skills.

Reading Ability and CT Skills

Because the CCTST is an English language instrument, and because of the similarities in the question frames used on the CCTST with those used in reading assessment, a small study was conducted to determine the possible correlation between the CCTST and the Nelson-Denny Reading Test. The Nelson-Denny Reading Test, a widely used instrument, reports scores in four areas: Vocabulary, Comprehension, Total Score and Reading Rate. The computation for Total Score used in this study was the sum of the Vocabulary Score and the Comprehension Score.

Forty-two students enrolled in Reading 290 were pretested in September of 1989 using the Nelson-Denny Reading Test. These students were enrolled in one or another of the two sections taught by the same instructor. In Nov. '89 these two sections participated in the CCTST experiment by completing the CCTST as a posttest. They had not been given the CCTST in any earlier form. The mean score on the CCTST for this group of 42 students was 17.42 with a standard deviation of 3.7815. Table 8 reports the three

statistically significant correlations discovered to obtain between the CCTST score and the Nelson-Denny scores.

Table 8

Nelson-Denny Reading Scores and CCTST Results

N-D Score	Cases	Mean	St. Deviation	rho	Sig. of rho
Vocabulary	42	73.21	13.7991	.4609	*p<.01
Comprehension	42	61.14	5.1541	.4248	*p<.01
N-D Total	42	134.17	17.4718	.4936	*p<.001
Reading Rate	42	419.19	92.6718	.1275	not significant

Native English Language Ability and the CCTST

As the results above indicate, the CCTST presumes the ability to read and understand English, the language in which the instrument is written. As one would suspect, there are also strong correlations between SAT scores and reading ability.[4] One might also suspect GPA to be connected to English language ability in an important way, since the language of instruction in the California State University system, where this research was conducted and these data gathered, is English. One might predict, therefore, that the scores of native English speakers as compared with the scores of non-native English speakers would be significantly different on a number of indicators. The California State University system is a richly diverse environment. Since 19% of both the Nov. posttest group and the Feb. pretest group were non-native English speakers, a number of interesting language group comparisons were possible. Table 9 reports statistically significant differences.

Table 2

Differences by English as Native Language

	Native English Speakers	Non-Native English Speakers	Change	Prob.	Cases Eng.	Cases Non-Eng.
H.S. Prep-Eng	7.87	7.19	-.68	*p=.001	465	115
H.S. Prep-math	6.32	6.84	.52	*p=.002	466	116
SAT verbal score	437	329	-108	*p=.001	497	108
SAT math score	488	470	-18	p=.076	497	108
CSU ELM test	51.2	55.0	3.8	*p=.001	320	84
CSU EPT test	150.1	138.4	-11.7	*p=.001	322	111
College GPA	2.70	2.68	-.02	p=.659	702	171
Feb. Pretest	16.65	13.78	-2.87	*p=.001	388	91
Nov. Posttest	17.59	13.73	-3.86	*p=.001	373	89

Note that the scores of non-native English speakers are significantly lower on both the pretest and the posttest. More importantly, the non-native English speakers show virtually no change from pretest to posttest.[5] Also, with the exception of the SAT-math, there were statistically significant differences between native English speakers and non-native English speakers on all the other standardized testing instruments. However, contrary to expectations, their college GPA's were very similar. Might this fact be fully accounted for on the assumption that grading practices reflect real learning more accurately than standardized tests? However, in those cases where the results of these standardized tests are used as decisive criteria, non-native English speakers can be expected not to fare as well as native English speakers. **That there is no significant difference from pretest to posttest for non-native English speakers indicates that the CCTST instrument is not appropriate for the assessment of college students who are not native English speakers.**

Instructor-Related Factors and CT Development

In addition to departmental affiliation, six other instructor-related variables suggested themselves as factors which might plausibly have an effect on the development of students' critical thinking skills. The six instructor-related factors examined were:

1. tenured vs. non-tenured status,

2. full-time vs. part-time employment status,

3. doctorate vs. non-doctorate preparation.

4. gender (on the hypothesis that social stereotypes might influence students' receptiveness to being taught to think logically by persons of one sex as opposed to the other),

5. the number of years of college level teaching experience,

6. the number of CT sections taught in the previous 36 months,

One-way analysis of variance indicated that the first four factors were not related in a statistically significant way to Nov. '89 and May '90 combined posttest results. If we consider the mean scores on the CCTST to be partial indicators of an instructor's effectiveness in developing CT skills in students, the analyses for sex and full-time/part-time employment suggest that those two are virtually irrelevant to the CT teaching effectiveness. Table 10 presents the findings for these six variables, only the last two of which turn out to be statistically significant.

Table 10

Instructor-Related Factors and Student Success on the CCTST Posttest

Factor	F-Statistic	df	Sig of F	Eta Sq
Tenure vs. Non-Tenure	F = 1.5469	1, 724	p =.2140	.0021
Full-Time vs. Part Time	F = .0249	1, 724	p =.8747	.0000
Ph.D. vs. Non-Ph.D.	F = 2.7123	1, 724	p =.1000	.0037
Instructor's Gender	F = .1139	1, 723	p =.7359	.0002
Years of College Teaching	F = 2.4579	13, 712	*p =.0029	.0429
CT Sections in Past 3 Yrs	F = 2.5186	12, 712	*p =.0030	.0407

The Eta squared values indicate that, considered in isolation from everything else, roughly 4% of the variance in CCTST posttest scores is attributable to the teaching experience factor in general and roughly 4% relates to recent CT teaching experience. However considered in combination with other student-related factors, such as SAT scores and GPA, their effect is not significant. When these two factors were added to the several others used in the two multiple regression models discussed above, both were eliminated from the final regression equations.

Pierson correlation analysis on these two experience factors suggests they do not have a linear relationship to success on the CCTST. The graphic representations of the findings of this study suggests that some interesting non-linear relationships might exist between teaching experience and teaching effectiveness. In Table 11 the years of experience are in parentheses.

Table 11

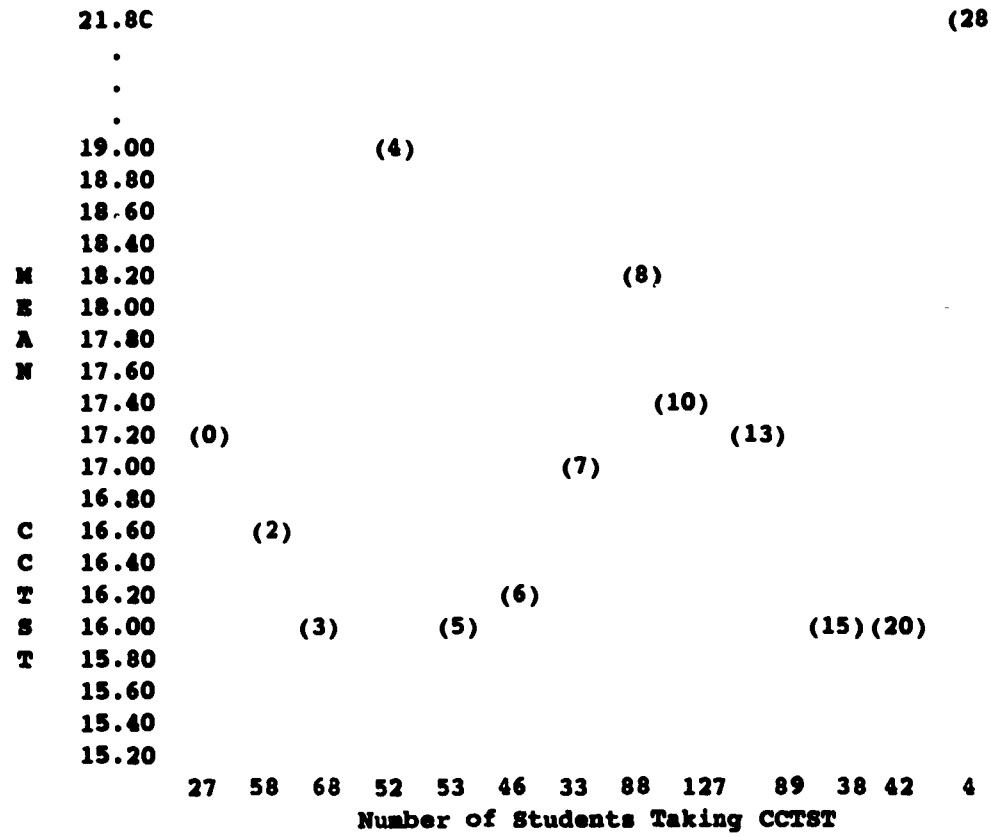
Relationship of Years of Teaching Experience and CCTST Posttest Scores

```
    19.00                                          (11)(12)
    18.80
    18.60
    18.40
M   18.20
E   18.00
A   17.80                          (7)
N   17.60
    17.40                                                  (15)
    17.20  (0)
    17.00                    (5) (6)      (10)
    16.80           (3)
C   16.60                                                      (18)
C   16.40
T   16.20                                                              (30)
S   16.00               (4)                                        (21)
T   15.80
    15.60
    15.40      (1)
    15.20
           27  32  51  96  89  33  76  32  52  44  44  66  38  46
                      Number of Students Taking CCTST
```

In Table 12 the numbers of CT sections taught in the 36 months prior to the semester during which the data is being gathered is reported in parentheses. The numbers of cases are reported under each parenthetical number of sections. Notice that the number of cases for prior sections (28) is only 4, otherwise the numbers of cases are large enough to support the CCTST means reported

Table 12

Sections of CT Taught in Prior 36 Months and CCTST Posttest Scores



The six factors reviewed here are frequently regarded to be important in deciding the general fitness of candidates for instructional positions. At the least, they are thought of as crude indices of teaching effectiveness. But in this research they turned out either

not to be significant or to have relationships to the outcome variable which were unexpectedly complex. Such findings lead to speculations about faculty evaluation policies which this investigator consigns to the wisdom others. However, of greater importance is what these negative findings suggest about those factors which might, indeed, make a difference -- specifically the utilization of particular CT classroom activities, projects, instructional materials, and pedagogy. Future research may confirm the emerging consensus among advocates of CT in the college curriculum that who teaches the CT course is probably less important than how the CT course is taught.

Hypothesis: We All Teach CT

In view of the results reported here and in Technical Report #1, CT enthusiasts can justly feel proud that their instructional efforts lead to measurable improvements in students' CT skills. However, it is widely argued in the academy that all good instruction -- almost, but not quite by definition -- does (or should) nurture students' CT skills. Clearly some find it to be an implied criticism to suggest that because CT courses emphasize CT outcomes, other courses in the curriculum do not. In view of the findings presented here, this reaction, however, is inappropriate. Pride in one's teaching does not require that one teach all things. An honest evaluation of one's value as an instructor, or of the value of a course or program of study, should not presume that CT skill development must be an intended outcome. Now that this outcome can be distinguished and measured separately from others, questions as to whether or not it should be part of a given course of study become curricular judgments and the success of achieving such an outcome becomes an empirical matter.

Wise and sensible educators emphasized the importance of learning how to think

logically long before the CT movement blossomed in the late nineteen eighties. Indeed, it is not unreasonable to expect that the entire baccalaureate educational process might have been intended to result in the enhancement of those skills we now identify with the name "critical thinking." However, whether it does or not is now a testable question.

To evaluate the hypothesis that the baccalaureate experience in general leads to a growth in CT skills it was predicted that the CT of veteran college students would be stronger than those of younger or less experienced students. Operationally, if this were so, then one might predict a positive linear correlation between CT skills and age, or between CT skills and the number of college units earned. However, as indicated in Table 1 above, efforts to discover such results using the CCTST failed.

A second way of trying to test the intuition that all good instruction includes CT instruction, was to isolate a specific course, not unlike the required CT course, and determine if a measurable growth in CT skills occurred in that course. For this purpose Introduction to Philosophy was selected. Intro. to Philosophy, like the four CT courses, is a lower division general education offering with a student clientele which is comparable to the cadre enrolled in the four approved CT courses. Instructors of Intro. Phil. indicate that while teaching CT is not their main goal, they do spend some time, perhaps a week or two, on common fallacies of reasoning. Also they do emphasize and attempt to model clear and logical thinking throughout the semester.

As indicated in Technical Report #1 in Nov. '89, 126 Introduction to Philosophy students took the CCTST under the same controlled conditions as obtained in the Nov. '89 posttest of the four CT courses. In Feb. '90, 124 students from three matched sections of Intro. Phil. were pretested using the CCTST. The Feb. '90 pretest mean was 15.436 and the Nov. '89 posttest mean was 15.476 revealing a gain of +.04. The t-statistic for this

experiment was .08 and the null hypothesis, that there was no significant difference between the two groups, was retained with P=.938.

In May '90 these same three sections were given the CCTST as a posttest. The May '90 mean was 16.356 as compared to the Feb. '90 pretest mean of 15.722 for the 90 students who complete both the Feb. '90 pretest and the May '90 posttest. The difference (+.63) is not statistically significant (t-statistic =1.69, two-tail p=.94). To confirm that the spring and fall groups were reasonably comparable, one could compare the overall May '90 posttest mean of 15.722 with the Nov. '89 posttest mean of 15.476. The non-significant difference of 0.246 warrants the assumption that the CT skills of these groups are reasonably consistent semester to semester.

It may be the case that all good instructors teach CT, however the hypothesis that students learn CT as a natural by-product of their college education was not confirmed by this experiment. In courses were the development of CT was both the chief educational goal of instruction and assessment, measurable development in CT skills was evident on the CCTST. But in courses, such as Introduction to Philosophy, where instructors, while not neglecting CT, rightly emphasize other educational goals, development in CT skills, as measured by the CCTST, was not evident. This is not a criticism of Introduction to Philosophy or any other course. It is, rather, a candid acknowledgement, based on the evidence at hand, that curricular and pedagogical energies must be directed primarily toward CT skill development if such development is to be a measurable outcome of baccalaureate level general education.

Conclusion

Critical thinking skills, as measured on the CCTST, can be predicted by a combination of SAT verbal, SAT math, and GPA data. CT skills are positively correlated with reading ability and, hence, the use of the CCTST for non-native English speakers is strongly counter-indicated. Of those instructor-factors which are thought to be related to effectiveness in teaching CT skills, only years of teaching experience and prior experience teaching CT appear to be related, and their relationships are non-linear. Given the effectiveness of the CCTST as an assessment tool, it was applied to the hypothesis that CT skill development is a natural outcome of baccalaureate education. No evidence for that hypothesis, either in general, or by reference to a control group experiment, could be discovered. This result, however, need not be viewed negatively or with concern. Not all professors teach all subjects, not all professors teach all skills. The CCTST, as a student assessment tool, has strong concurrent validity with other important assessment devices and measures of student aptitude and achievement such as SAT, EPT, ELM, GPA, and Nelson-Denny Reading Test.

Technical Report #3 discusses analyses performed on additional student-related factors such as academic major, CT self-esteem, gender, and ethnicity. Technical Report #4 provides group norms for the overall CCTST score and for the CCTST sub-scores on analysis, evaluation, inference, deductive reasoning and inductive reasoning skills.

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Endnotes

(1) Unlike the sample for the Nov. posttest which was independent of other administrations of the CCTST, the same students were sampled for both the Feb. pretest and the May posttest.

(2) Enrollments in these four courses account for 85% of the CT enrollment at California State University, Fullerton with the majority of sections being found in the two Philosophy Dept. offerings.

(3) Findings related to factors such as academic major, CT self-confidence, gender, and ethnicity are treated in detail in Technical Report #3. However, these valuable human differences turn out not to be statistically significant in predicting CT skill results on the CCTST when one controls for those more telling differences among people, such as scholastic aptitude and reading ability.

(4) Twenty-six of the students for whom Nelson-Denny scores were available also had SAT scores on record. For these 26 cases the correlations of the SAT verbal score with the Nelson-Denny Vocabulary Score, Comprehension Score and Total Score were significant at $p < .001$. The correlations of the SAT math score with the Nelson-Denny Vocabulary and Total Score were significant at $p < .01$. Correlations with Nelson-Denny scores and GPA or college units earned were not statistically significant for these 26 cases.

(5) That non-native English speakers show no change after having completed an approved CT course should be a matter of major concern to the campus and the CSU system which require that all students satisfy a CT requirement. At the time of this research the CT requirement could not be satisfied by any means other than successfully completing an approved CT course. It is recommended that student outcomes research on non-native English speakers should be undertaken in the CSU to determine if such policies as this are equitable.