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# High-Performing Students with Low Critical Thinking Skills

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## HIGH-PERFORMING STUDENTS WITH LOW CRITICAL THINKING SKILLS

**Robert L. Williams and Susan L. Stockdale**

Definitions of critical thinking in the professional literature tend to share a common emphasis on the linkage between conclusions and related evidence (Jegede & Noordink, 1993; Nickerson, Perkins, & Smith, 1985; Watson & Glaser, 1964; Williams & Worth, 2001). Facione (1986) succinctly defined the notion of critical thinking in terms of argument construction and evaluation, which reflects the proposed linkage between conclusions and evidence. Our definition and psychometric measures of critical thinking targeted student ability to select conclusions that were most supportable from assumptions and evidence provided in critical thinking tests. One prominent critical thinking researcher (Halpern, 1993, 1998, 1999) affirmed that this ability to identify and generate supportable conclusions from credible information bases is fundamentally important in college coursework.

The importance of critical thinking has been linked to its potential both as a predictor and outcome variable in college courses (Williams, Oliver, Allin, Winn, & Booher, 2003; Williams & Worth, 2001; Williams & Worth, 2002). This relationship between predictor and outcome status is potentially reciprocal: high critical thinking contributes to success in a course, and success in a course contributes to higher critical thinking. Within this framework, high critical thinkers are more likely than low critical thinkers to achieve good grades in a course, and students achieving high grades are more likely than students achieving low grades to improve their critical thinking skills (Williams, Oliver, Allin, et al., 2003). Thus, low critical thinkers are at a disadvantage in two ways: they are more likely than high critical thinkers to achieve poor grades and less likely to improve their critical thinking.

Related research shows that low critical thinking skills substantially reduce the possibility of doing well in courses that require

considerable critical thinking (Bowles, 2000; Gadzella, Ginther, & Bryant, 1997; Wilson & Wagner, 1981). Some of our past research has shown that students making Ds or Fs in the target course, on the average, scored at the 3<sup>rd</sup> percentile on a national critical thinking test both at the beginning and end of the course (Williams, Oliver, & Stockdale, 2003). Low performers not only began the course with lower critical thinking, they also were much less likely to improve their critical thinking skills than high performers (Williams, Oliver, Allin, et al., 2003). Some poor performers actually declined in critical thinking during the course (Williams, Oliver, Allin, Winn, & Booher, in press).

Notwithstanding these linkages between low critical thinking and poor course performance, some students who begin courses with low critical thinking skills manage to earn high grades. We have found this to be the case even in courses that emphasize critical thinking and have stringent grade standards (Williams, Oliver, & Stockdale, 2003). With the odds very much against their making high grades in such courses, how do these students manage to perform at a high level? Do they find ways to compensate for their low critical thinking, perhaps by working harder than other students? Or, do they improve their critical thinking skills, which in turn contribute to better performance in a course? In courses with a variety of outcome measures (e.g., essay quizzes, multiple-choice exams, course projects, homework assignments, and class participation), do high-achieving low critical thinkers take a different route to high grades than high-achieving high critical thinkers?

The answers to these questions could have considerable practical relevance in determining how to maximize the course performance of low critical thinkers, who typically achieve low to average grades. Although high critical thinkers potentially could help low critical thinkers improve their thinking skills, what might work better would be for the high-performing low critical thinkers to teach other low critical thinkers ways to compensate for thinking limitations. The strategies used by high critical thinkers to achieve course success may not be equally efficacious for low critical thinkers. Instructors can also help low critical thinkers perform better academically by first identifying study habits and course priorities that are differentially effective for low and high critical thinkers. Then, instructors

could provide the structure and continuing supervision for low-performing low critical thinkers to apply the study habits of high-performing low critical thinkers consistently, efficiently, and effectively.

Thus, this study first involved grouping students on high and low critical thinking skills according to test norms and then determining which students within these groups performed well and which performed poorly in a large undergraduate course. The basic question was what differentiates the course practices of high-performing low critical thinkers from those of high-performing high critical thinkers and those of low-performing low critical thinkers. The high-performing low critical thinking group was contrasted with the other two groups on a variety of support (e.g., class attendance, class participation, class notetaking) and credit variables (e.g., essay quizzes, multiple-choice exams, course project) in the course. Our objective was to determine how the high-performing low critical thinking group differed from the other groups on specific credit activities, work patterns during the course, and selected cognitive variables.

## Method

### *Participants*

All students were enrolled in an undergraduate Human Development course required for students entering the Teacher Preparation program at a large state university. The data were collected over six semesters in classes ranging from 25 to 55 students, with the student enrollment per semester ranging from 149 to 215 for combined sections. Only students who took a critical thinking pretest and obtained a grade in the course served as participants ( $N = 795$ ). Approximately two-thirds of the students were sophomores and juniors, with the remaining students including freshmen, seniors, and graduate students. Women in the course outnumbered men 3 to 1.

The participants in this study were divided into two large samples (Groups A and B) based on which critical thinking test they took during the course. In the early semesters of the study students

took the *California Critical Thinking Skills Test* (Facione & Facione, 1994) and in the later semesters the *Watson-Glaser Critical Thinking Appraisal-Form S* (Watson & Glaser, 1994). Two instruments were used to broaden the base for conclusions relative to the linkage between critical thinking and course performance. For both instruments, norms provided in the respective critical thinking test manuals were used to identify high and low critical thinkers. As will be explained later, both Groups A and B were further subdivided according to (a) when their critical thinking instrument was given or (b) what combination of target variables was used with the group. See Table 1 for a flow chart of what samples took which critical thinking instrument during the course across the six semesters.

*Group A.* These students ( $n = 434$ ) were divided into quartiles based on norms provided in the *California Critical Thinking Skills Test* manual (Facione & Facione, 1994, p. 13). Then students who scored either in the lowest ( $n = 149$ , 34% of Group A) or highest quartile ( $n = 74$ , 17% of Group A) were further subdivided into high and low performers based on their grade in the course. Students obtaining an A or B were designated as high performers

Table 1: Subsample Participation by Semester

Semester	Sample	ns	Critical thinking instrument				CT/G <sup>a</sup> group ns		
			CCTST <sup>b</sup>		WGCTA-S <sup>c</sup>		LCT-	LCT-	HCT-
			Pre	Post	Pre	Post	LG <sup>d</sup>	HG <sup>e</sup>	HG <sup>f</sup>
1,2,3	A1	287	x				41	16	39
4	A2	147	x	x			9	20	20
5	B1	164			x	x	5	12	20
6	B2	197			x	x	13	10	15
Totals		795					68	58	94

Note: <sup>a</sup>CT/G group represents Critical Thinking/Grade group. <sup>b</sup>CCTST represents California Critical Thinking Skills Test. <sup>c</sup>WGCTA-S represents Watson-Glaser Critical Thinking Appraisal-Form S. <sup>d</sup>LCT-LG represents Lowest Critical Thinking-Low Grade. <sup>e</sup>LCT-HG represents Lowest Critical Thinking-High Grade. <sup>f</sup>HCT-HG represents Highest Critical Thinking-High Grade.

and those making a D or F as low performers. Because practically no Highest-Quartile critical thinkers made a D or F in the course, Group A provided only three usable subgroups: Lowest-Quartile Critical Thinkers with Low Grades ( $n = 50$ ), Lowest-Quartile Critical Thinkers with High Grades ( $n = 36$ ) and Highest-Quartile Critical Thinkers with High Grades ( $n = 59$ ). Percentage wise, 11.5% of Group A students were identified as Lowest-Quartile Critical Thinkers with Low Grades (LCT-LG), 8.3% as Lowest-Quartile Critical Thinkers with High Grades (LCT-HG), and 13.6% as Highest-Quartile Critical Thinkers with High Grades (HCT-HG).

Some Group A students took the *California Critical Thinking Skills Test* (CCTST) only at the beginning of the course (Group A1) and others took the CCTST both at the beginning and end of the course (Group A2). Although a total of 287 Group A1 students and 147 Group A2 students met the two general criteria for inclusion in the study, only 96 of the students in Group A1 met the specific criteria for inclusion in one of our three comparison groups (LCT-LG, LCT-HG, or HCT-HG), and only 49 students in Group A2 met the specific criteria for one of the comparison groups. Extrapolation from data in Table 2 indicates that less than 3% of students in the lowest quartile of critical thinking in the combined A1 and A2 groups made an A in the course, whereas 28% of students in the highest quartile of critical thinking in the combined A1 and A2 groups made an A. Most of the LCT-HG students in both the A1 and A2 samples made Bs rather than As, whereas a substantial percentage of the HCT-HG students in the two A samples made As.

*Group B.* This group ( $n = 361$ ) consisted of students who took the *Watson-Glaser Critical Thinking Appraisal-Form S* (WGCTA-S) pre-test and obtained a final grade in the course. Participants in Group B also were administered the WGCTA-S at the end of the course. More stringent criteria were used in Group B than in Group A in selecting the lowest critical thinkers and high-grade performers. Those scoring at or below the 5th percentile on the test norms were designated as lowest critical thinkers ( $n = 145$ , 40% of Group B) and those scoring at or above the 75th percentile on the test norms as highest critical thinkers ( $n = 45$ , 13% of Group B). We reduced the

Table 2: Letter-Grade Distributions for High and Low Critical Thinking Groups Per Sample

Sample	High critical thinking (HCT)						Low critical thinking (LCT)					
	HCT <i>n</i>	A	B	C	D	F	LCT <i>n</i>	A	B	C	D	F
A1	47	32%	51%	13%	0%	4%	101	2%	14%	43%	25%	16%
A2	27	22%	52%	22%	0%	4%	48	4%	38%	39%	17%	2%
B1	24	83%	4%	13%	0%	0%	60	20%	43%	28%	7%	2%
B2	21	71%	14%	10%	5%	0%	85	12%	36%	36%	12%	4%

*Note:* The HCT group for samples A1 and A2 consisted of students scoring in the top quartile of the normative distribution for the *California Critical Thinking Skills Test-Form A*. The HCT group for samples B1 and B2 consisted of students scoring at or above the 75th percentile of a normative distribution for college graduates provided in the test manual for the *Watson-Glaser Critical Thinking Appraisal-Form S*. The LCT group for samples A1 and A2 consisted of students scoring in the bottom quartile of the normative distribution for the *California Critical Thinking Skills Test-Form A*. The LCT group for samples B1 and B2 consisted of students scoring at or below the 5th percentile of the normative distribution for college graduates provided in the test manual for the *Watson-Glaser Critical Thinking Appraisal-Form S*. The letter-grade percentages were based on the respective HCT and LCT *ns*.



critical thinking percentile for inclusion in Group B to prevent a disproportionate number of students from being included in the low critical thinking group. Even with this adjustment in the criterion for low critical thinking in Group B, the percentage of low critical thinkers was slightly higher in Group B (40%) than in group A (37%).

In addition to the criterion change for low critical thinking, the grade criterion was changed for high performance in Group B (restricted to students making an A in the course). This restriction was based on a much higher percentage of As in Group B than in Group A. With the adjustment in the grade criterion for high-performance in Group B, the percentage of students achieving As in the high and low critical thinking groups was very similar to the percentage of students achieving As or Bs in Group A. The low-performance criterion continued to be either a D or F in the course, as was the case with Group A. With the adjustment in both the criterion for low critical thinking and the criterion for high-grade performance, approximately 5% of Group B students were classified as LCT-LG ( $n = 18$ ), 6% as LCT-HG ( $n = 22$ ), and 10% as HCT-HG ( $n = 35$ ).

Because some changes were made in the variables tracked over the two semesters of Group B data collection, students in the first B semester were designated as Group B1 ( $n = 164$ ) and students in the second B semester as Group B2 ( $n = 197$ ). Extrapolation from data in Table 2 indicates that approximately 14% of the lowest critical thinking students in the combined B1 + B2 groups achieved an A in the course, whereas 74% of the highest critical thinking students in the combined B groups achieved an A. The grade distributions for the highest and lowest critical thinkers shown in Table 2 indicate a high percentage of As for highest critical thinkers in Group B but mainly Bs and Cs for lowest critical thinkers. Because more non-exam credit options were available in the Group B than the Group A samples, grades were generally better across critical thinking levels in Group B than in Group A (most students had their greatest difficulty on the exams). However, across all samples (A1, A2, B1, and B2), the probability of making an A averaged 8 times higher in the highest critical thinking groups than in the lowest critical thinking groups (see Table 2).

*Critical Thinking Instruments*

Over the course of the six semesters in which the data were collected, one of two critical thinking tests was given each semester: *California Critical Thinking Skills Test-Forms A and B* (Facione & Facione, 1994) and *Watson-Glaser Critical Thinking Appraisal-Form S* (Watson & Glaser, 1994). Both are multiple-choice tests and provide norms against which our students were compared. A critical thinking instrument was given only on a pre-course basis in Group A1 and on a pre and post basis in the remaining three samples (A2, B1, and B2).

*The California Critical Thinking Skills Test (CCTST)*. This instrument has 34 items on each of two forms (Form A and B), with related assumptions/information provided on which to base answers to the questions. The test can be administered in 45 minutes. Scores can range from 0 to 34, with the central tendency norms virtually the same for Forms A and B (mean = 17.52 for Form A and 17.49 for Form B; median = 18 for both forms). The standard deviation also is similar for the two forms (4.05 for Form A and 4.79 for Form B). The score equivalent to the 25th percentile was exactly the same for Forms A and B (14.00), and the minimal score for the top quartile was similar for the two forms (21.00 for Form A and 22.00 for Form B). In the current study, Form A was used as the pre-course measure and Form B as the post-course measure. Only Group A participants took either Form A or both Forms A and B of the CCTST. The test manual reported the internal consistency for the CCTST to be .70, and indicated that scores are moderately correlated with scores on several other cognitive instruments (e.g., SAT-Verbal, SAT-Math, and Nelson-Denny Reading Test).

*Watson-Glaser Critical Thinking Appraisal (WGCTA)*. This instrument is probably the most widely used measure of critical thinking at the college level. The particular form used in this study (Form S) is an abbreviated version of the original Form A (Watson & Glaser, 1980). Form S was designed primarily for adults, including college students. It can be administered in approximately 30 minutes. The WGCTA contains 40 items, with 2 to 5 options per item. All the information needed to answer each question is provided in the test itself. Scores on the WGCTA-Form S can range from 0 to 40. In a

normative group composed almost entirely of college graduates, a score of either 23 or 24 marked the 5th percentile and a score of 34 the 75th percentile. The mean score for this normative sample was 32.48 and the standard deviation was 5.0. The internal consistency and test-retest reliability for Form S both were .81. Scores on the instrument were also reported to be moderately related to a variety of academic and professional measures. Only Group B students in the current study took the WGCTA-S (Table 1).

### *Credit Variables*

The study was done in the context of a highly organized course divided into five units emphasizing different developmental themes: physical, cognitive, psychological, social, and character. A study guide that included questions over both the readings and class discussions provided a framework for notetaking. Sections of the course across semesters used basically the same format, with some adjustments made in credit-earning variables across semesters but not within semesters. The sections were taught by different instructors who used the same course format each semester and were supervised by the same senior professor. Grades were assigned on a criterion-referenced basis, with 90% and above total credit earning an A, 80 to 89% of the credit warranting a B, 70 to 79% of the credit meriting a C, and 69% and below credit resulting in a D or F.

Although credit measures in the course varied somewhat across semesters, several were consistent across all semesters: brief unit essay quizzes, unit multiple-choice exams, a comprehensive multiple-choice final exam, and a course project. In some semesters, students also received credit for a group problem solving activity, homework assignments, class participation, reviews of research articles, and class attendance.

*Essay quizzes.* Near the end of each unit, students were presented two factual questions from the readings section of the study guide. Students could choose either question to answer in one paragraph, taking no more than 5 minutes to construct and submit their answer. Each question required only recall of specific information in the reading materials. Depending on the semester, the quiz answers were scored on either a 0 to 5 or a 0 to 10 scale. A 0 score was *either*

*no answer or totally inaccurate answer* and the top score was a *complete and accurate answer*. Past inter-rater reliability for scoring of the quizzes by pairs of graduate teaching assistants typically has been at least .90 (Williams & Worth, 2002). Unit quiz scores were combined to constitute a total quiz score, which usually accounted for about 5% of the credit in the course.

*Multiple-choice exams.* At the last class session in each unit, students also took either a 40-item or 50-item multiple-choice exam that encompassed most major issues in the unit. Close to two-thirds of the items required logical reasoning regarding course information, with many of the remaining items requiring both specific recall and logical reasoning (Wallace & Williams, 2003). At the end of the course, students took a comprehensive final exam (either 75 or 100 items) that was structured much like the unit exams. Unit exam scores potentially represented about 50% of course credit and the final exam another 20%.

*Course project.* Another credit product common to all semesters was a course project. Students selected a topical question from an instructor list of questions to answer in a five-page report. The student's answer was to be based on information gleaned from a variety of professional sources. Students first were given a set of guidelines as to how to construct the project report, with the instructions specifically delineating how much credit could be earned by following each guideline. When students submitted their projects, they turned in a self-rating of how well they had followed each guideline. A graduate teaching assistant (GTA) then used the same guidelines in evaluating the credit earned on the project. Scores on the project could range from 0 to 50, with credit potentially amounting to about 13% of the course credit. Past inter-rater reliability between pairs of GTAs evaluating the course project has averaged about .76.

*Additional credit variables.* A number of additional outcomes were used in various semesters of the course. These included credit for attendance, class participation, homework assignments, in-class group problem solving, reviews of research articles, and reports on workshop participation. Typically, each of these measures amounted to 5% or less of course credit; but taken together could total as much as 20% of the course credit.

*Support Variables*

Support variables refer to processes/products/abilities that presumably contributed to student performance in the course, but for which students received no direct credit. Because of changes in the course across semesters, some variables that were support variables one semester were upgraded to credit variables in other semesters. Attendance and class participation are examples of actions that began as support variables but were later upgraded to credit variables.

Overall, the dimensions used as support variables at various points in the data collection included attendance, in-class and out-of-class notetaking, participation in class discussion, use of course web site, improvement in course knowledge, improvement in critical thinking, out-of-class performance on practice exams, pre-course generic vocabulary, ACT scores, and prior GPA. Across all semesters, attendance was checked by circulating a sign-in sheet during class. Notetaking was assessed by examining student notes in the student's study guide at the end of the course. Notes were assessed primarily in terms of number of questions answered in the study guide, but the assessment formula also included weighting for completeness and accuracy of individual answers to questions. Students obtained a notetaking score for both readings and in-class notes, as well as a total notetaking score. Interrater reliability in the assessment of student notes has ranged in the mid to high .90s (Williams & Eggert, 2002). Participation in class discussion was assessed by GTAs' tracking how frequently each student participated in the discussion each class session.

The remaining support variables were assessed through tests and questionnaires. Students reported their ACT and GPA on a demographic questionnaire at the beginning of the course. Students indicated on a Likert-type scale at the end of the course how frequently and when they had used the course web site. Students in three of the samples were given a critical thinking test at the beginning and end of the course, permitting an assessment of change in critical thinking during the course. Students in one sample were given a non-credit essay test over major concepts in the course both at the beginning and end of the course, permitting an assessment of their improvement in course knowledge during the course. Students in another sample were administered a generic vocabulary test at the beginning

of the course. Finally, students in one sample were given practice exams to take outside of class. They received credit for submitting the completed answer sheets for these exams, but the credit was not proportional to the number of questions answered correctly.

## Results

Analysis of results mainly targeted differences between the high-performing low critical thinking group and the other two critical thinking/grade groups on a variety of support and credit variables. In the main, group differences relative to support and credit variables were established through analysis of variance and ad hoc multiple comparisons. Analyses are presented separately for each sample (A1, A2, B1, and B2). Significant differences reported in the text generally were at the .001 level. Finally, effect sizes were computed for critical thinking/grade-performance comparisons on credit and support variables across samples.

The Results section first presents the differences between the three critical thinking/grade group means on credit and support variables. An examination of the credit variables indicated whether students emphasized different credit activities in qualifying for high and low grades. Examination of support variables indicated the extent to which students in the different groups could be differentiated on the basis of cognitive abilities and work habits.

### *Group Differences in Credit Variables*

As described in the Method section, the total sample was first divided into Groups A and B depending on which critical thinking test students took. Group A took the CCTST and Group B took the WGCTA-S. Group A was further subdivided into which students took the CCTST only at the beginning of the course (Group A1) and which took the CCTST both at the beginning and end of the course (Group A2).

*Group A.* The findings are presented first for Group A1 (participants who took the CCTST only at the beginning of the course). For all credit-producing comparisons (exam and non-exam) between the three critical thinking/grade groups in Group A1, the LCT-HG and HCT-HG

groups did not differ significantly, but both obtained significantly ( $p < .001$ ) higher performance scores than the LCT-LG (see Table 3). Despite no significant credit differences between the two high-grade groups, the LCT-HG participants generally achieved slightly lower raw scores on credit-producing variables than did the HCT-HG students. This pattern probably accounted for the higher percentage of As in the HCT-HG group (38.5%) than in the LCT-HG (12.5%).

Table 3: Critical Thinking/Grade Group Differences on Credit and Support Variables in Group A1

Course variables	Variable means			
	LCT-LG <sup>a</sup> ( <i>n</i> = 41)		LCT-HG <sup>b</sup> ( <i>n</i> = 16)	HCT-HG <sup>c</sup> ( <i>n</i> = 39)
Credit variables				
Exam total	188.26	<	273.06	= 283.13
Unit exams	149.41	<	212.00	= 218.67
Final exam	38.85	<	61.06	= 64.46
Non-exam total	62.07	<	93.25	= 95.72
Essay quizzes	8.34	<	17.56	= 18.67
Group problem solving	23.56	<	32.69	= 31.67
Project	30.17	<	43.00	= 45.38
Support variables				
Attendance	16.05	<	20.94	= 20.33
Total notes	14.25	<	41.40	> 32.37
Reading notes	6.78	<	24.20	> 18.29
Class notes	7.47	<	17.20	= 14.09

*Note:* The symbols < and > represent a significant difference (generally at the .001 level), whereas the symbol = represents a non-significant difference between means. <sup>a</sup>LCT-LG represents Lowest-Quartile Critical Thinking with a Low Grade. <sup>b</sup>LCT-HG represents Lowest-Quartile Critical Thinking with a High Grade. <sup>c</sup>HCT-HG represents Highest-Quartile Critical Thinking with a High Grade.

A comparison of the support variables for the A1 groups showed a somewhat different pattern than for the credit-producing variables (see Table 3). Again, both the LCT-HG and HCT-HG groups scored higher on attendance and all notetaking variables than the LCT-LG group, but the LCT-HG group also scored significantly higher than

the HCT-HG group on two of three notetaking variables. The LCT-HG group did significantly better than the HCT-HG on both total notetaking and readings notetaking. Inasmuch as readings notetaking was done entirely outside of class, the LCT-HG group appeared to give more time and effort to mastering course content between class sessions than did the HCT-HG group. In absolute terms the LCT-HG group also did better notetaking in class than the HCT-HG group, though not significantly better. Given that notetaking has been the best overall predictor of course performance in the past (Williams & Worth, 2002), some students apparently compensated for their low critical thinking skills by giving extensive attention to their notetaking.

The A2 credit-variable pattern was somewhat different from that of the A1 students (see Tables 3 and 4). Similarly to A1, the low critical thinkers with high grades did better on all credit variables than did the low critical thinkers with low grades. In contrast to the pattern for A1 students, A2 students with high critical thinking plus high grades did significantly better on the exam variables than students with low critical thinking plus high grades. The difference in exam scores for the two high-grade groups may have contributed to the difference in the grade distributions within those two groups: 30% of the high critical thinking/high-grade group achieved As, whereas only 10% of the low critical thinking/high-grade group achieved As. Similar to the A1 students, the two A2 groups with high grades did equally well on the non-exam variables.

Because the A2 sample took the *California Critical Thinking Skills Test* both at the beginning and end of the course, comparisons were made between the three critical thinking/grade groups on their change in critical thinking during the course (see Table 4). The low critical thinking/high-grade group was the only group to improve critical thinking scores during the course. In fact, the other two groups actually declined somewhat in critical thinking from the beginning to the end of the course. On a non-credit essay test over major concepts in the course given at the beginning and end of the course (labeled knowledge difference in Table 4), the two high-grade groups showed similar gains in course knowledge (with both gaining significantly more knowledge than the low critical thinking/low-grade group).



Table 4: Critical Thinking/Grade Group Differences on Credit and Support Variables in Group A2

Course variables	Variable means				
	LCT-LG <sup>a</sup> (n = 9)		LCT-HG <sup>b</sup> (n = 20)		HCT-HG <sup>c</sup> (n = 20)
Credit variables					
Exam total	170.44	<	225.90	<	239.35
Unit exams	128.89	<	165.55	<	174.45
Final exam	41.56	<	60.35	<	64.90
Non-exam total	49.88	<	62.25	=	62.00
Essay quizzes	8.89	<	17.55	=	16.95
Project	40.88	<	44.70	=	45.05
Support variables					
Critical thinking difference <sup>d</sup>	-1.75	<	2.10	>	-2.47
Knowledge difference <sup>e</sup>	10.75	<	22.94	=	28.47
ACT	20.75	=	22.06	>	26.89
GPA	2.79	<	3.22	=	3.39

*Note:* Symbols < and > represent a significant difference (generally at the .001 level), whereas the symbol = represents a non-significant difference between means. <sup>a</sup>LCT-LG represents Lowest-Quartile Critical Thinking-Low Grade. <sup>b</sup>LCT-HG represents Lowest-Quartile Critical Thinking-High Grade. <sup>c</sup>HCT-HG represents Highest-Quartile Critical Thinking-High Grade. <sup>d</sup>Critical thinking difference represents the pre- and post-course difference on critical thinking assessment. <sup>e</sup>Knowledge difference represents the pre- and post-course difference on knowledge assessment.

Another indication of superior effort by the low critical thinking/high-grade group was the attainment of a GPA significantly higher than that of the low critical thinking/low-grade group and comparable to that of the high critical thinking/high-grade group. Although the reported ACT scores of both low critical thinking groups were significantly lower than the ACT scores for the high critical thinking/high-grade group, the two low critical thinking groups did not differ significantly on their ACT scores. Based on the assumption that GPA is affected more by work habits than are ACT scores, it appears that the LCT-HG students generally made better use of their cognitive skills than did the LCT-LG students.

*Group B.* For the first data set (Group B1) in which the *Watson-Glaser Critical Thinking Appraisal* was used to assess critical thinking, significant group differences were obtained between the two low critical thinking groups for all exam and non-exam variables, including multiple-choice exams, essay quiz totals, course projects, reviews of course research articles, workshop credit, and class participation (see Table 5). Although the LCT-HG and HCT-HG groups did not differ significantly on any of the credit variables, the raw score means showed a tendency for the HCT-HG to do slightly better on most credit variables than did the LCT-HG group. The LCT-LG group scored significantly lower than the other two groups on all the credit variables.

The pattern of support-variable differences for the B1 critical thinking/grade groups was substantially different from their pattern of credit-variable differences (see Table 5). The two low critical thinking groups did not differ significantly on any of the support variables, but the two high-grade groups differed significantly on all the support variables except use of the course web site. Specifically, the LCT-HG group was significantly higher than the HCT-HG on critical thinking gains and significantly lower on ACT and GPA. Although the three groups did not differ significantly on their self-reported use of the course web site, raw score means indicated that the LCT-HG group reported using the web site more than the other groups. The course web site was used to access announcements, handouts, transparencies, and grade records.

For the second data set (B2) in which the Watson-Glaser was used to assess critical thinking, significant group differences were obtained for all the credit-producing variables: unit exams, final exam, course project, quizzes, attendance, and homework (see Table 6). All three critical thinking/grade groups differed on exam total and unit exams: the HCT-HG group performed better than the LCT-HG group, which in turn performed better than the LCT-LG group. However, the HCT-HG and LCT-HG groups did not differ significantly on all other credit variables, though both groups performed significantly better than the LCT-LG on the final exam, essay quizzes, course project, attendance, and homework. Overall, the two high-grade groups were more similar on non-exam than exam performance.

Table 5: Critical Thinking/Grade Group Differences on Credit and Support Variables in Group B1

Course variables	Variable means			
	LCT-LG <sup>a</sup> (n = 5)		LCT-HG <sup>b</sup> (n = 12)	HCT-HG <sup>c</sup> (n = 20)
Credit variables				
Exam total	157.20	<	243.33	= 251.65
Unit exams	118.80	<	177.17	= 183.20
Final exam	38.40	<	66.17	= 68.45
Non-exam total	52.00	<	108.58	= 111.60
Essay quizzes	9.60	<	20.58	= 22.80
Project	21.40	<	47.58	= 48.15
Article reviews	15.20	<	24.00	= 23.70
Workshop reports	1.80	<	9.17	= 9.75
Class participation	4.00	<	7.25	= 7.20
Support variables				
Critical thinking difference <sup>d</sup>	5.00	=	6.91	> - 1.11
Course web site use	16.00	=	20.10	= 18.57
ACT	24.00	=	23.91	< 28.94
GPA	2.53	=	3.07	< 3.49

*Note:* Symbols < and > represent a significant difference (generally at the .001 level); the symbol = represents a non-significant difference. <sup>a</sup>LCT-LG represents Lowest Critical Thinking-Low Grade. <sup>b</sup>LCT-HG represents Lowest Critical Thinking-High Grade. <sup>c</sup>HCT-HG represents Highest Critical Thinking-High Grade. <sup>d</sup>Critical thinking difference represents the pre- and post-course difference on critical thinking assessment.

The critical thinking/grade groups in the B2 data set differed significantly on a variety of support variables: performance on practice exams, change in critical thinking during the course, pre-course generic vocabulary, and overall GPA. As with the official unit exams taken in class, the LCT-HG group did significantly better on the combined practice exams than the LCT-LG group but significantly worse than the HCT-HG group. Also consistent with the previous samples, the LCT-HG group made significantly greater gains in

critical thinking than did the HCT-HG group. The three groups were significantly different in their entry-level generic vocabulary: the HCT-HG group demonstrated a better general vocabulary than the LCT-HG group, which in turn had a better vocabulary than the LCT-LG group. With respect to GPAs upon entering the course, the LCT-HG reported a higher GPA than the LCT-LG group and an equivalent GPA to the HCT-HG group.

Table 6: Critical Thinking/Grade Group Differences on Credit and Support Variables in Group B2

Course variables	Variable means				
	LCT-LG <sup>a</sup> (n = 13)		LCT-HG <sup>b</sup> (n = 10)		HCT-HG <sup>c</sup> (n = 15)
Credit variables					
Exam total	211.17	<	296.70	<	321.27
Unit exams	147.00	<	206.20	<	228.87
Final exam	64.17	<	90.50	=	92.40
Non-exam total	94.41	<	122.89	=	121.82
Essay quizzes	33.27	<	45.89	=	45.68
Project	33.46	<	48.40	=	47.53
Attendance	16.67	<	18.90	=	19.21
Homework	7.25	<	10.00	=	9.50
Support variables					
Practice exams	63.00	<	91.25	<	101.53
Critical thinking difference <sup>d</sup>	1.83	=	4.30	>	-1.80
Pre-course vocabulary	20.77	<	26.60	<	38.00
GPA	2.36	<	3.56	=	3.51

*Note:* The symbols < and > represent a significant difference (generally at the .001 level) between comparison means, whereas the symbol = represents a non-significant difference.

<sup>a</sup>LCT-LG represents Lowest Critical Thinking-Low Grade. <sup>b</sup>LCT-HG represents Lowest Critical Thinking-High Grade. <sup>c</sup>HCT-HG represents Highest Critical Thinking-High Grade. <sup>d</sup>Critical thinking difference represents the pre- and post-course difference on critical thinking assessment.

*Effect-Size Comparisons between Critical Thinking/Grade Groups*

Table 7 shows the mean effect sizes and ranges of effect sizes across samples for comparisons between the low critical thinking/high-grade group and the other critical thinking/grade groups. In the computation of the effect sizes, the LCT-HG group was considered the focal group and either the LCT-LG or HCT-HG group was considered the comparison or control group. Thus, in comparing the differences in means between the LCT-HG group and either comparison group, the standard deviation of the comparison group was used in the computation of effect size.

Table 7: Summary of Average Effect Sizes for Critical Thinking/Grade-Group Comparisons

	LCT-HG vs. LCT-LG	LCT-HG vs. HCT-HG
Credit variables		
Total exams	2.97 (1.67 to 4.38) <sup>a</sup>	-1.12 (-2.18 to -0.44)
Unit exams	3.01 (2.05 to 4.09)	-1.16 (-2.46 to -0.33)
Final exam	1.95 (1.15 to 3.07)	-.72 (-1.08 to -0.48)
Total non-exams	1.73 (1.55 to 2.01)	-.11 (-.04 to 0.25)
Support variables		
Attendance	-.89	.03
Total notes	2.54	.56
Readings notes	2.26	.53
Class notes	2.19	.47
Exam practice	4.08	-1.14
CT difference <sup>b</sup>	.63 (.42 to .74)	2.27 (1.17 to 3.78)
Knowledge difference	1.44	-.53
Web site use	.63	.22
Pre-vocabulary	.90	-1.88
ACT	.22 (-.03 to .46)	-1.94 (-2.16 to -1.73)
GPA	1.48 (1.20 to 2.05)	-.38 (-.82 to .10)

*Note:* Because LCT-HG was the focal group and the other groups the comparison groups, the LCT-LG standard deviation was the denominator in the computation of effect sizes between LCT-HG vs. LCT-LG; whereas the HCT-HG standard deviation served as the denominator in the computation of effect sizes between LCT-HG vs. HCT-HG. <sup>a</sup>Range of effect sizes across samples. <sup>b</sup>Difference between pre and post critical thinking scores.

Generally, the effect sizes were larger for comparisons between the two low critical thinking groups than for comparisons between the two high-grade groups. Three exceptions to this trend were the pre to post differences in critical thinking scores, pre-vocabulary scores, and ACT scores. In these particular cases the effect sizes were larger for comparisons between the two high-grade groups than comparisons between the two low critical thinking groups. Several support-variable effect sizes showed better performance for the LCT-HG group than for the HCT-HG group: total notes, reading notes, class notes, gains in critical thinking, and use of the course web site. The LCT-HG group consistently gained more in critical thinking during the course than either of the other critical thinking/grade groups. Comparisons for credit measures between the LCT-HG group and the other groups showed greater differences for exams than for non-exams. Although the LCT-HG group did much better than the LCT-LG group on both exams and non-exams, the LCT-HG group did not do as well on either exams or non-exams as the HCT-HG group. However, the differences between the latter two groups were considerably greater for exams than for non-exams. In fact, the average effect size for non-exams in the comparison between the LCT-HG and HCT-HG groups was only  $-.11$ , much below the level generally considered to have practical significance.

Several findings summarized in Table 7 appear to be particularly important. First, the high-performing low critical thinkers did much better on exams, all of which required substantial critical thinking, than did the low-performing low critical thinkers. However, despite their generally good performance on the exams, the high-performing low critical thinkers did not do as well as the high-performing high critical thinkers on the exams. The high-performing low critical thinkers did better on notetaking and improvement in critical thinking than the high-performing high critical thinkers, but apparently not enough to close the gap between the exam scores of the two groups. In contrast, high-performing low critical thinkers did essentially as well on non-exam credit options as the high-performing high critical thinkers. With respect to all study-habits variables, high-performing low critical thinkers did better than low-performing low critical thinkers. Thus, there appears to be a pervasive difference

in the way that high-performing and low-performing low critical thinkers approached study in the course.

## Discussion

Although students with high entry-level critical thinking generally did better in course performance than students with low entry-level critical thinking, the former group was more homogeneous than the latter group with respect to grades. High critical thinkers generally achieved As and Bs and almost never Ds and Fs. Although low critical thinkers mainly achieved Bs and Cs, a substantial percentage of them also achieved As and Bs or Ds and Fs. Thus, the principal focus of the study was to compare the pattern of credit- and support-variable scores for the low critical thinkers who did well in the course versus the patterns of both the low critical thinkers who did poorly in the course and high critical thinkers who did well.

### *Contributors to Group Differences*

What appears to account for differences in performance between the three target groups, especially the two low critical thinking groups? An examination of support variables indicates that the difference between the latter groups is more attributable to work habits than to ability. The two low critical thinking groups were generally equivalent in their entry-level thinking skills and their reported ACT scores. The support variable that provided the strongest evidence for an ability difference between the low critical thinking groups was pre-course vocabulary, in which case the low critical thinking/high-grade students did better than the low critical thinking/low-grade students. However, because generic vocabulary development may relate in part to how hard students voluntarily work on their vocabulary during the college years, we are hesitant to interpret vocabulary status strictly as a cognitive factor.

Work-habits differences between the two low critical thinking groups apparently were not unique to the target course. Differences in GPA suggest more generalized work-habits differences between

the two low critical thinking groups. Despite equivalent ACT and pre-course critical thinking scores for the two low critical thinking groups, the high-performing low critical thinkers apparently were expending greater effort in their college work than the low-performing low critical thinkers. What is especially impressive about the assumed work habits of the high-grade/low critical thinkers is that their GPA approached that of high-performing students with much higher critical thinking skills.

The most pivotal work-habits difference between the high performing low critical thinkers and the other two groups in the target course related to notetaking. The low critical thinking high-grade students not only did much better in total notetaking, readings notetaking, and class notetaking than the low-performing low critical thinkers, they also did better on these notetaking variables than the high-performing high critical thinkers. It appears that the high-performing low critical thinkers may be compensating for their cognitive limitations by taking complete and accurate notes. Given that notetaking is both an extremely labor-intensive and powerful activity for improving one's grade, the high-grade low critical thinkers wisely invested considerable time in constructing complete and accurate notes (Williams & Eggert, 2002).

Another potential indication of effort is the extent to which students improved their knowledge and thinking skills in the course, even when no credit was given for improvement on either dimension. In the one sample where a non-credit assessment of course knowledge was done both at the beginning and end of the course, the low critical thinking/high-grade group gained significantly more knowledge than the low critical thinking/low-grade group. Plus, the knowledge gains of the low critical thinking/high-grade group were not significantly different from those of the high critical thinking/high-grade group.

Comparisons of the three samples in which critical thinking was assessed both at the beginning and end of the course showed that the low critical thinking/high-grade group changed more favorably in their generic critical thinking than the other two groups. Despite the fact that the overall pattern of scores for the various samples (A1, A2, B1, and B2) evidenced little improvement in critical thinking, the low critical thinking/high-grade subgroup showed modest



improvement in critical thinking skills (which may have facilitated their performance on exams). Although having less room for improvement in critical thinking than low critical thinkers, high critical thinkers in the target course in the current study typically have improved their critical thinking skills more than low critical thinkers (Williams, Oliver, Allin, et al., 2003, in press).

### *Implications for Teaching and Learning*

Most students with high critical thinking skills will likely perform well in college courses, irrespective of how courses are organized and the level of assistance provided by instructors. For students with lower critical thinking, student work habits and instructor assistance could make a substantial difference in performance. Fortunately, some low critical thinkers appear to have figured out how to compensate for low critical thinking skills. In fact, because they have generally done well in college, these students may perceive themselves as good thinkers. In some cases, low critical thinkers who did poorly on the first exam in the target course improved their performance by the second exam and continued to do well the rest of the course.

Helping students comparable to our low critical thinking low-performing students will be a formidable task for instructors. These students will not bring a record of sterling academic performance to their courses. Our research suggests that they will have work-habit deficiencies related both to amount of effort and type of effort. They may have reduced confidence in their ability due to a poor academic record or they may simply not recognize how hard they should work and what things they should do to maximize their performance. To be helpful to these students, instructors must have some method for identifying them early in the course. A pre-course critical thinking assessment would provide some indication as to who will need special assistance, and GPA would be another early indicator of how well a student is likely to do in a given course. Students with low critical thinking and low GPAs most likely will need instructor assistance with their work habits to make acceptable grades in a large entry-level course organized similarly to the target course in the current study.

For courses with a substantial content base, the most productive work habit to target would be student notetaking, especially notetaking done out of class over reading materials. The course targeted in this study included a highly specific study guide in which students took all of their notes. Thus, it was easy for both students and teachers to determine whether students were addressing critical course content in their notes. The more that teachers structure notetaking, the better low-performing students can organize their notes. However, close monitoring of how these students are doing in their notetaking also is indispensable. When their notetaking is not monitored and supervised, low-performing students tend to be overly brief and somewhat off-target in their notetaking (Williams & Eggert, 2002; Williams & Worth, 2002).

#### *Limitations of the Current Research*

Perhaps the greatest limitation of the current research relates to the extent to which the conclusions could be generalized to a broad spectrum of general education students. Broad generalization would hinge on the assumption that students in a large human development course at one relatively large state university would be similar to students in other large entry-level courses at other major universities. The findings would be most generalizable to highly structured courses that emphasize critical thinking in course assessments. Boding well for generalizability of the results of the current study is the fact that the data were collected over 6 semesters (3 years), with the findings being generally consistent across semesters. Most findings proved replicable within the context of the current study.

Over the course of the six semesters when the data were collected, several changes were made in the selection criteria for the critical thinking/performance groups and in course requirements and support variables monitored. In addition, a number of different instructors taught the course over the three-year period of data collection. These variations somewhat limit the feasibility of direct comparisons across semesters. Although two critical thinking instruments were used, both are nationally recognized measures of critical thinking. The upper criterion for low critical thinking was the 25<sup>th</sup> percentile (test norms) for the first instrument and the 5<sup>th</sup> percentile

(test norms) for the second instrument, the criterion being lowered for the second instrument to reduce the percentage of the local sample in the low critical thinking group. Also, the criterion for high performance was elevated from an A or B in the first two samples to an A in the last two samples. Because a number of non-exam credit options were added for the last two samples, a higher percentage of students achieved high grades than in the first two samples. With respect to instructor differences over the period of data collection, all instructors used the same basic format, content, and assessment procedures. Plus, the same senior professor supervised all instructors.

All the data collected in this study were quantitative in nature. Undoubtedly, much could have been learned about the differences between the three comparison groups by inviting students to share their perceptions of course experiences via individual interviews or focus groups. It would have been particularly illuminating to determine how the high- and low-performing low critical thinkers viewed their ability to do well in the course and their understanding of what it would take for them to do well in courses similar to the course featured in this research. The specific strategies that the high-performing low critical thinkers used to compensate for thinking limitations might have been teased out better through interviews than through the data collected in the current study. Another important mode of data collection would be having students keep logs of out-of-class study activities, designating the amount of time spent on each activity. A cautionary note is that this kind of data collection would be particularly vulnerable to student exaggeration.

Some of the data collected for the study could be questioned on the basis of precision. For example, having students self-report attendance on a circulated sign-in sheet leaves open the possibility that students could sign in absent friends. In each class one GTA was responsible for grading student written work and keeping all course records. Because this GTA frequently interacted with the students, the GTA learned the names of students early in the semester. As is the custom in many classes, most students identified a preferred seating area early in the semester and generally sat in that area throughout the semester. A relatively constant seating pattern typically made it easy for the GTA to determine who was absent on a particular day and whether a signature had been forged.

One of the groups included in the study received some credit for class participation. The GTA who kept the records noted the number of comments made by each student during the discussion. This approach obviously reflected only the frequency of student responses rather than the quality of those responses. Although quality of response would be a very important dimension to record, we felt that it would be too difficult for a first-year GTA to rate quality while also keeping track of the number of comments. Nonetheless, future research might arrange for videotaping class discussion, which would allow the rater to stop the tape after each comment to judge its contribution to the discussion. This would be far more labor intensive than simply recording the number of responses, but might provide more discriminating data as to the cognitive depth of comments in the comparison groups.

Although the limitations of the current study represent fruitful areas for future research manipulations, they also may add robustness to the patterns highlighted in the study. Despite changes across semesters in the critical thinking instruments used, in the critical thinking criterion for placement in the low critical thinking groups, in the grade criterion for placement in the high performance group, in instructors who taught the course, and in the array of credit and non-credit variables, the differences among the three performance groups remained generally consistent across the six semesters in which the data were collected. Even though the data came from one large course in one university, the diversity of groups and research manipulations across semesters suggests that the findings could reflect fundamental differences in the way the three target groups approach highly organized general education courses.

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