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ABSTRACT

Critical thinking has important implications for classic learning issues such as transfer of knowledge and application of problem-solving skills to novel situations. The goal of this study was to identify some of the important correlates of critical thinking, in terms of motivation, use of cognitive learning strategies, and classroom experiences. Participants (N=758) were college students attending three midwestern institutions (a community college; a small private college; and a comprehensive university) during the 1987-88 school year. Twelve classrooms were sampled, spanning three disciplines: biology (three classes, N=219); English (three classes, N=110); and social science (six classes, N=429). The Motivated Strategies for Learning Questionnaires (MSLQ) was administered to students at the beginning and at the end of the winter 1988 school term. The results of the analyses lend further support for the positive relationship between "deep" processing (in this case, critical thinking) and an intrinsic goal orientation. The relationship between critical thinking and a mastery orientation, however is tempered by the content domain. Intrinsic goal orientation is a significant, positive predictor of critical thinking for biology and social science students, but not for English students, at both the pretest and posttest. Metacognitive self-regulatory strategies were consistently positively related to critical thinking, both across domains and at the two time points. In summary, this study supported the positive relationship between motivation, deep strategy use, and critical thinking. (ABL)

Critical thinking and its relationship to motivation, learning strategies, and classroom experience

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Abstract

The aim of this study was to identify some of the motivational, learning strategy, and classroom experiences that are most strongly related to critical thinking. We focused on intrinsic goal orientation as a motivational variable that may enhance cognitive engagement (Elliott & Dweck, 1988; Graham & Golan, 1991; Pintrich & Garcia, 1991). In terms of learning strategies, we chose rehearsal, elaboration, and metacognitive self-regulatory strategies (regulating, monitoring, and planning) as representative of surface- and deep-processing of information (Entwistle & Marton, 1984; Marton, Hounsell, & Entwistle, 1984; Weinstein & Mayer, 1986) which may relate to differences in critical thinking. We used classroom perceptions of instructor effectiveness, the difficulty of the course, and of the degree of collaboration perceived by the students as experiences which may promote or detract from critical thinking (Ames & Archer, 1988; McKeachie, 1986; Smith, 1977). Finally, we examined differences between biology, English, and social science classes to identify domain differences in the relative importance of the motivational, learning strategy, and classroom experiences in levels of students' critical thinking (Stodolsky, 1988; Stodolsky, Salk, & Glaessner, 1991).

Critical thinking and its relationship to motivation. learning strategies, and classroom experiences

Teresa Garcia and Paul R. Pintrich

We define critical thinking as the degree to which students report applying previous knowledge to new situations to solve problems, reach decisions, or make critical evaluations with respect to standards of excellence (McKeachie, Pintrich, Lin, Smith, & Sharma, 1990; Pintrich, Smith, Garcia, & McKeachie, 1991). As such, critical thinking has important implications for classic learning issues such as transfer of knowledge and application of problem-solving skills to novel situations (Halpern, 1989; Nickerson, Perkins, & Smith, 1985). The goal of this study was to identify some of the important correlates of critical thinking, in terms of motivation, use of cognitive learning strategies, and classroom experiences.

There is a large and growing body of research directed at examining the interface between motivation and cognition (e.g., Elliott & Dweck, 1988; Graham & Golan, 1991; Pintrich & Garcia, 1991). This research has shown that students' goals are related to their degree of cognitive engagement. Engaging in a task for reasons such as interest, mastery, challenge -- having an intrinsic goal orientation -- is related to "deeper" processing, whereas engaging in a task for reasons such as demonstrating one's ability, getting a good grade, or besting others -- having an extrinsic goal orientation -- is related to shallower levels of information processing. This line of research has demonstrated the importance of motivation in students' cognitive engagement; accordingly, our model includes intrinsic goal orientation as a factor that may positively influence critical thinking. Previous studies have examined the links between motivation and learning strategies, but there has been little research on the links between motivation and critical thinking.

Researchers focusing on students' strategies for learning have also contributed to our understanding of reasoning and thinking in the classroom. Entwistle and his colleagues (e.g., Entwistle & Marton, 1984; Marton, Hounsell, & Entwistle, 1984) discuss students' information processing in terms of the use of deep and surface learning strategies. Greater cognitive engagement is associated with using deep strategies such as elaboration, organization, as well as metacognitive strategies involving monitoring, regulating, and planning (cf. Bransford, Sherwood, Vye, & Reiser, 1986; Weinstein & Mayer, 1986). Surface strategies such as rote rehearsal, copying passages from the text, or rewriting class notes indicate a lesser degree of cognitive engagement. Critical thinking, by definition, is a form of higher-order cognitive engagement (e.g., Halpern, 1989); students who use deep strategies may then demonstrate greater levels of critical thinking, relative to students who tend to use surface strategies. We have included rehearsal, elaboration, metacognitive self-regulatory strategies as correlates of critical thinking to test this proposition.

Critical thinking may not only be influenced by students' motivation and use of learning strategies, but also by what happens in the classroom. Students' reasoning and thinking are affected by classroom processes and task structures (Ames & Archer, 1988; Halpern, 1989; McKeachie, 1986; Nolen, 1988; Smith, 1977). Students who are allowed to work in small, collaborative peer groups demonstrate greater cognitive engagement. Higher levels of cognitive engagement are also reported by students who rate their instructors as enthusiastic, effective, and responsive.

Finally, classroom processes and their relationship to students' motivation and cognition may be traced to domain differences (Stodolsky, 1988; Stodolsky, Salk, & Glaessner, 1991). Different domains demand different instructional practices and task structures, and the importance of particular strategies or motivational outlook may vary by content area. The tasks and cognitive demands on students in the natural sciences may be markedly different from those faced by students in the social sciences, in composition classes, or mathematics, so the impact of motivation, learning strategies, and classroom experiences on critical thinking may differ by discipline.

Therefore, the research questions that will guide the reporting of results are as follows: 1) What are the relationships between motivation, learning strategies, and critical thinking?; 2) What is the relationship between classroom experience and critical thinking?; and 3) How do the relationships between motivation, learning strategies, classroom experience, and critical thinking vary by subject domain?

Method

Subjects

Participants of this study were 758 college students attending three midwestern institutions (a community college; a small, private college; and a comprehensive university) during the 1987-1988 school year. Twelve classrooms were sampled, spanning three disciplines: biology (three classes, total n = 219); English (three classes, total n = 110); and social science (six classes, n = 429). Males (49.1%) and females (50.9%) are proportionately represented, and the majority of our sample is white (84%). Over half of the respondents were in their first year of college (57%).

The Motivated Strategies for Learning Questionnaire (Pintrich, McKeachie, Smith, Doljanac, Lin, Naveh-Benjamin, Crooks, & Karabenick, 1988) was administered to students at the beginning and at the end of the Winter 1988 school term. These data were collected on a volunteer basis, and subjects received no monetary compensation for their participation.

Measures

The Motivated Strategies for Learning Questionnaire (MSLQ) is a self-report, Likert-scaled instrument (1 = not true of me, to 7 = very true of me) designed to measure student motivational beliefs and strategy use. The 1988 version of the MSLQ consists of

40 motivation and 65 cognitive strategy items, which comprise a total of 20 scales. The five pretest and posttest MSLQ scales used were: intrinsic goal orientation; rehearsal strategies; elaboration strategies; metacognitive self-regulatory strategies; and critical thinking. The posttest MSLQ includes an additional 30 items designed to tap into students' course perceptions. Our three course perceptions scales, instructor effectiveness, course difficulty, and collaborative learning are based on a factor analysis of the classroom perception items. Subjects' mean scale scores were used for analyses.

Intrinsic goal orientation (4 items: time 1 alpha = .73; time 2 alpha = .75) refers to the degree to which a student engages in a learning task for reasons such as mastery, challenge, curiosity (e.g., "I prefer coursework that arouses my curiosity, even if it is difficult"). The rehearsal strategies scale (4 items: time 1 alpha = .64; time 2 alpha = .66) is a measure of the level of memorization and repetition a student uses when studying (e.g., "When I study I practice saying the material to myself over and over"). Elaboration strategies (7 items: time 1 alpha = .65; time 2 alpha = .73) is an index of the degree to which a student tries to paraphrase, summarize, or create analogies (e.g., "I write brief summaries of the main ideas in my lecture notes"). Our measure of metacognitive self-regulatory strategies (13 items: time 1 alpha = .78; time 2 alpha = .83) assesses three general processes: planning, regulating, and monitoring (e.g., "I try to think through a topic and decide what I'm supposed to learn from it rather than just read it over when studying"). Critical thinking (5 items: time 1 alpha = .75; time 2 alpha = .78) is a measure of the extent to which students report applying previous knowledge to new situations to solve problems, reach decisions, or make critical evaluations with respect to standards of excellence (e.g., "When a theory, interpretation, or conclusion is presented in class or in the readings, I try to decide if there is good supporting evidence"). Our course perceptions scales tap three factors: instructor effectiveness (10 items, alpha = .90; e.g., "The instructor explains material well"); course difficulty (4 items, alpha = .76; e.g., "This course requires too much work compared to other courses carrying the same credit hours"); and collaborative learning (2 items, alpha = .80; e.g., "Students often work together to complete assignments").

Results

Descriptive statistics and bivariate relationships

Means and standard deviations for these constructs are located in Table 1. The variables show a slight negative skew, with means hovering at about 5.0. Mean levels of critical thinking decreased from time 1 to time 2; a paired t-test indicates that this decrease is statistically significant, t(376) = 3.91, p = .000. Additional paired t-tests show significant decreases in intrinsic goal orientation (t(384) = 2.50, p = .013), rehearsal (t(377) = 2.51, p = .012), and elaboration (t(375) = 2.56, p = .011). These time 1 to time 2 decreases are consistent with many of our previous findings (e.g., Pintrich et al., 1991; Pintrich & Garcia, 1991).

Critical thinking, intrinsic goal orientation, rehearsal, elaboration, and metacognitive self-regulatory strategies are positively correlated with one another. As shown in Table 1, the correlations between the five constructs at the pretest range from .23 to .66, and correlations between the posttest measures of these variables range from .33 to .75. Note that although the five constructs are positively related to one another, the relationship between critical thinking and rehearsal (r = .23 at time 1, and .28 at time 2) is weaker than those between critical thinking and intrinsic goal orientation (r = .50 at time 1; .57 at time 2), elaboration (r = .57 at time 1; .64 at time 2), and metacognitive self-regulatory strategies (r = .59 at time 1; .64 at time 2). Test-retest correlations between pairs of the same constructs range from .57 to .66. Correlations between different constructs at time 1 and time 2 range from .18 to .52.

Insert Table 1 about here

Correlations between the three course perception variables and critical thinking, intrinsic goal orientation, rehearsal, elaboration, and metacognitive self-regulatory strategies are presented in Table 2. Instructor effectiveness is moderately related to critical thinking (r = .13 with time 1 critical thinking, and r = .21 at time 2 critical thinking), and more strongly related to intrinsic goal orientation and learning strategies (correlations range from .16 to .25 with time 1 measures, and from .28 to .40 with time 2 measures). Perceptions of course difficulty do not seem to be related to critical thinking, motivation, and learning strategies in a linear fashion, with bivariate correlations ranging from -.09 to .07. Collaborative learning is moderately related to critical thinking (r = .10 with time 1 critical thinking, and r = .13 with time 2 critical thinking). Working with other students is also positively related to levels of intrinsic goal orientation and use of learning strategies (r's range from .05 to .14 with time 1 measures of motivation and strategies; r's range from .16 to .30 with time 2 measures of motivation and learning strategies).

Insert Table 2 about here

<u>Differences between disciplines</u>

Although the three disciplines (biology, English, and social science) show no significant differences in mean levels of pretest critical thinking (F(2,678) = .26, n.s.), there are significant differences in posttest levels of critical thinking, and pretest and posttest measures of intrinsic goal orientation and learning strategies (see Table 3). Biology, English, and social science also significantly differ in mean levels of perceived instructor effectiveness, course difficulty, and collaborative learning. Post hoc Scheffe tests show a consistent pattern that indicates biology is different from English and social science. At both the pretest and posttest, biology students reported higher levels of intrinsic goal orientation, rehearsal, elaboration, and metacognitive self-regulatory strategies, compared to English and social science students. At time 2, however, students in English reported higher levels of critical thinking (M = 4.81) than did biology (M = 4.60) or social science (M = 4.38) students. In terms of course perceptions, biology students perceived their classes to be of higher quality (M = 5.82) and more difficult (M = 2.82) than English and social science students. Biology also has the highest perceived level of collaborative learning (5.30), followed by social science (3.83) and English (2.99).

Insert Table 3 about here

Critical Thinking at Time 1

Given that critical thinking is correlated with motivation, learning strategies, and classroom experiences (Tables 1 & 2); and that there are significant domain differences in mean levels of the constructs of interest (Table 3), we moved to multiple regression as a multivariate tool for examining differences in the relative importance of motivation and different types of learning strategies on levels of critical thinking. Table 4 contains the results of four parallel regressions: the first regression was done using the entire sample, and the other three are the same regressions done separately by discipline. These equations enter time 1 intrinsic goal orientation, rehearsal, elaboration, and metacognitive strategies as predictors of time 1 critical thinking.

The first regression was done on the entire sample, and included two dummy variables to test for domain differences (Biology and English are coded 0/1, so entering these two variables into the equation makes social science the comparison group). At time 1, intrinsic goal orientation (beta = .33), elaboration strategies (beta = .27), and metacognitive self-regulatory strategies (beta = .33) have comparable effects on critical thinking, whereas rehearsal strategies are not significantly related to critical thinking in this multivariate analysis (beta = -.03). It is interesting to note that the oneway ANOVA showed no significant differences between the three disciplines in pretest critical thinking; however, after controlling for motivation and learning strategies, being in biology is associated with significantly lower levels of critical thinking, compared to social science (beta = -.08). Forty-five percent of the variance in pretest critical thinking can be accounted for by incoming levels of motivation and learning strategies, as well as discipline differences.

Within-domain regressions show that rehearsal is not significantly related to critical thinking in the three domains. Rehearsal strategies are marginally significant in the equations for biology and for English. Rehearsal is negatively related to time 1 critical thinking in biology (-.10), but positively related to pretest levels of critical thinking in English (.18). Biology (R^2 = .46) and social science (R^2 = .47) show the same pattern of results as above, with intrinsic goal orientation, elaboration, and metacognitive self-regulatory strategies positively related to critical thinking. However, testing the same model with the English sample shows that the only significant predictor of critical thinking is use of metacognitive self-regulatory strategies. Accordingly, slightly less variance in pretest critical thinking is accounted for in the English sample (R^2 = .38).

Insert Table 4 about here

Critical Thinking at Time 2

The second set of regression equations enter time 2 intrinsic goal orientation, rehearsal, elaboration, and metacognitive self-regulatory strategies as predictors of time 2 critical thinking. In order to examine the effects of classroom experiences on students' critical thinking, the posttest regression models also include perceptions of instructor effectiveness, course difficulty, and collaborative learning (see Table 5).

Insert Table 5 about here

The first regression, using the aggregated sample and the two dummy variables for discipline, show the same pattern of effects for motivation and learning strategies at the posttest as in the pretest. That is, time 2 rehearsal strategies (beta = -.06) are not significantly related to posttest critical thinking, but intrinsic goal orientation (beta = .25), elaboration (beta = .28), and metacognitive self-regulatory strategies (beta = .35) are significant positive predictors of critical thinking at the posttest. The only significant course perception predictor is course difficulty (beta = .10): students who perceived their courses as difficult tended to report higher levels of time 2 critical thinking. After adjusting for motivation, use of learning strategies, and classroom perceptions, biology students reported significantly lower levels of critical thinking (beta = -.08), and English students reported significantly higher levels of critical thinking (beta = .10), compared to their social science counterparts. Slightly more than half of the variance (R^2 = .54) in posttest critical thinking is accounted for by time 2 motivation, strategy use, course perceptions, and discipline differences.[1]

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[1] When pretest level of critical thinking is included in this regression, variance explained increases to 65%. The effects of motivation, strategy use, and being in English are unchanged when time 1 critical thinking is included. However, course difficulty drops out as a significant predictor (beta decreases to .05).

Once again, the effects of motivation, strategy use, and course perceptions on critical thinking at time 2 differ between domains. For biology classes, the effects of perceived instructor effectiveness (beta = -.04), course difficulty (beta = .08), and collaborative learning (beta = .10) are washed out after adjusting for posttest levels of motivation and strategy use. At time 2, rehearsal is a significant negative predictor (beta = -.19) of critical thinking, whereas intrinsic goal orientation (beta = .30), elaboration (beta = .28), and metacognitive self-regulatory strategies (beta = .32) have comparably strong, positive effects on critical thinking. All told, just over half of the variance in posttest critical thinking in the biology classes is attributable to motivation and strategy use (R^2 = .52).[2]

Much like the pretest findings, the only significant predictor of posttest critical thinking in English is metacognitive self-regulatory strategies (beta = .56). Intrinsic goal orientation, rehearsal, elaboration, and course perceptions were not significantly related to time 2 critical thinking. Thus the bulk of the variance explained (R^2 = .52) in posttest critical thinking is related to planning, regulating, and monitoring processes.[3]

Posttest critical thinking in the social science courses (as in the pretest regression) is positively and significantly related to intrinsic goal orientation (beta = .28), elaboration (beta = .34), and metacognitive self-regulatory strategies (beta = .30) at time 2. Time 2 rehearsal strategies are not significantly related to posttest critical thinking in a linear fashion. Perceptions of instructor effectiveness and collaborative learning are unrelated to time 2 critical thinking, but course difficulty is a significant positive predictor of critical thinking in the social sciences (beta = .14). Almost sixty

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[2] When pretest level of critical thinking is included in this regression, variance explained increases to 67%. When time 1 critical thinking is accounted for, the effects of intrinsic goal orientation and metacognitive self-regulatory strategies are unchanged, but the effects of time 2 rehearsal and elaboration strategies on posttest critical thinking are washed out (betas decrease to -.01 and .09, respectively).

[3] Including time 1 critical thinking into the posttest model makes no difference in the results, in terms of the magnitude of the betas or percent of variance accounted for by the variables in the equation.

percent of the variance in critical thinking at time 2 is accounted for by motivation, strategy use, and perceptions of course difficulty ($R^2 = .59$).[4]

Finally, in order to make a more stringent test of the links between motivation, strategy use, classroom experiences, and critical thinking, we used *time 1* measures of motivation and strategy use and time 2 classroom perceptions to predict *time 2* critical thinking (see Table 6). Regressing posttest critical thinking on this set of variables gave similar results to the regressions reported above, although percents of variance explained are lower.

Insert Table 6 about here

For the model we used to test the entire sample, being in English is positively related to time 2 critical thinking (beta = .14), as is having an intrinsic goal orientation (beta = .17), using elaboration strategies (beta = .13) and using metacognitive self-regulatory strategies (beta = .38). Time 1 use of rehearsal strategies is negatively related to time 2 reports of critical thinking. After adjusting for pretest levels of motivation and strategy use, the only measure of classroom perceptions that is statistically significant is collaborative learning (beta = .13). Just over a third of the variation in posttest critical thinking can be accounted for by motivation, strategy use, and classroom experiences ($R^2 = .35$).[5]

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[4] An additional 10% of variance is accounted for by including time 1 critical thinking in the regression equation; doing so washes out the effect of perceptions of course difficulty, but the relationship between motivation, strategy use, and critical thinking at time 2 remains unchanged.

[5] Including time 1 critical thinking as a predictor in this equation explains an additional 12% of the variance in time 2 critical thinking. However, the effects of time 1 intrinsic goal orientation and rehearsal are washed out, and the effect of metacognitive self-regulatory strategies is decreased (beta decreases from .38 to .22). Perceived instructor effectiveness becomes a significant predictor (beta = .10).

The models tested separately by domain show the same patterns of differences. Time 1 use of rehearsal strategies is significantly negatively related to time 2 critical thinking (beta = -.18) in biology, but not in English or social science. Metacognitive self-regulatory strategies at the pretest are positively related to posttest critical thinking in all three domains (betas are .40, .38, and .38 for biology, English, and social science, respectively): again, use of these metacognitive self-regulatory strategies is the only significant predictor in the English model.

Discussion

Previous research has shown how an orientation towards mastery learning has positive effects on depth of information-processing (e.g., Graham & Golan, 1991; Pintrich & Garcia, 1991); the results of our analyses here lend further support for the positive relationship between "deep" processing (in this case, critical thinking) and an intrinsic goal orientation. The relationship between critical thinking and a mastery orientation, however, is tempered by the content domain. Intrinsic goal orientation is a significant, positive predictor of critical thinking for biology and social science students, but not for English students, at both the pretest and the posttest. Although the bivariate correlations between intrinsic goal orientation and critical thinking at the two time points are positive (r's range from .11 to .50) for students in English, multivariate analyses showed that the most powerful predictor of critical thinking in composition classes was the use of metacognitive self-regulatory strategies. The key difference between English and the two other domains may be that our English courses were *composition* classes. Critical thinking in English may mean critically evaluating one's own and other's writing. Planning, regulating, and monitoring are processes which are crucial to effective composition; therefore, metacognitive awareness, rather than motivation, becomes paramount in critically evaluating text.

Metacognitive self-regulatory strategies were consistently positively related to critical thinking, both across domains and at the two time points. The three processes that this scale taps, planning, regulating, and monitoring, define an awareness that may be one of the most important factors in reaching critical evaluations with respect to standards of excellence and applying previous knowledge to new situations to solve problems and reach decisions. Elaboration strategies (attempts to paraphrase, summarize, or draw analogies between different aspects of coursework) are also positively related to critical thinking (although not significantly so for English). It seems that "deep" strategy use fosters critical thinking: not unexpectedly, cognitive engagement in trying to understand the material (use of elaboration and metacognitive self-regulatory strategies) appears to beget further cognitive engagement that implies going beyond the material to think critically about it.

Rote rehearsal strategies were not consistently related to critical thinking. Zero-order correlations between rehearsal and critical thinking were all positive; however, after adjusting for other strategies, motivation, course perceptions, and domain differences, the relationship between rehearsal and critical thinking was either nonexistent or slightly to moderately negative. We had expected that deep strategy use would be positively related to critical thinking, and surface strategy use would be negatively related to critical thinking. However, rehearsal in and of itself does not appear to enhance nor attenuate critical thinking. It may be the case that although rehearsal is considered to be a surface strategy, it <u>is</u> a form of cognitive engagement (albeit a shallower form); cognitive involvement, in any manifestation, may simply be a necessary, but not sufficient precursor of critical thinking.

Students' evaluations of instructor effectiveness were not significantly related to critical thinking. Course difficulty and collaborative learning were significantly related to critical thinking, but these effects varied, depending on the regression model. When looking at the entire sample, and using *pretest* measures of motivation and strategies use, collaborative learning is a significant, positive predictor of critical thinking at the posttest. When looking at the entire sample and using *posttest* measures of motivation and strategy use, we find that posttest critical thinking is positively related to perceptions of course difficulty. The conclusion we can draw from these data is that in general, collaboration and discussion of class material with other students seems to promote critical thinking, and interestingly, course work students perceive as challenging may "force" students to think more critically.

With respect to domain differences, we found that biology students had the lowest level of critical thinking, after adjusting for motivation, cognitive strategy use, and course perceptions. This may be due to the nature of the material presented in a science class: students may have taken what they were presented to learn simply as factual, and did not seek to actively challenge what they may have interpreted as laws of nature. The higher level of critical thinking reported by students in English may also reflect the nature of the discipline. The questions which comprise our critical thinking scale (e.g., "Whenever I read an assertion or conclusion, I think about possible alternatives," "I often find myself questioning things I hear or read in this course to decide if I find them convincing," " I try to develop my own understanding of most topics, rather than only rely on the instructor's ideas") certainly tap into the processes involved in constructing and deconstructing text.

In summary, this study lends support to the positive relationship between motivation, deep strategy use, and critical thinking. These relationships held true across different regression models: when predicting *pretest* critical thinking with *pretest* motivation and cognition; when predicting *posttest* critical thinking with *posttest* motivation and cognition; and when predicting *posttest* critical thinking with *pretest* motivation and cognition. Collaborative learning and challenging course work are also positively related to critical thinking, but these classroom experiences are much weaker predictors of critical thinking, compared to individual differences in motivation and deep-processing strategies. The domain differences we found provide evidence supporting Stodolsky and her colleagues' claims of motivation and cognition varying by subject matter (Stodolsky, 1988; Stodolsky, Salk, & Glaessner, 1991), although a within-subject, repeated measures design would be a more powerful and stringent test of this assertion. The consistent effects of domain, and the varying effects of classroom experiences we found here indicate that the nature of the domain (e.g., the tasks students are given, the type of material involved), rather than actual classroom experience may be more closely linked to students' critical thinking. These data highlight the importance of motivation, cognitive engagement, and the subject domain in students' critical thinking.

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Table 1. Means, standard deviations, and correlations among pretest and posttest MSLQ scales. Minimum pairwise n = 447. Correlations with absolute values greater than or equal to .08 are significant at alpha = .05.

Note: Intrins = intrinsic goal orientation; rehears = rehearsal strategies; elabora = elaboration strategies; metacog = metacognitive self-regulatory strategies; critthk = critical thinking.

	Time 1					Time 2				
	intrins1	rehears1	elabora1	metacog1	critthk1	intrins2	rehears2	elabora2	metacog2	critthk2
intrins1	1.0									
rehears1	.23	1.0								
elabora1	.49	.42	1.0							
metacog1	.50	.45	.66	1.0						
critthk1	.50	.27	.57	.59	1.0					
intrins2	.59	.13	.35	.39	.37	1.0				
rehears2	.18	.57	.40	.33	.13	.33	1.0			
elabora2	.42	.32	.61	.59	.43	.60	.46	1.0		
metacog2	.36	.31	.50	.66	.35	.56	.49	.75	1.0	
critthk2	.41	.16	.44	.52	.63	.57	.28	.64	.64	1.0
Mean	5.31	5.14	4.88	4.86	4.71	5.16	5.04	4.81	4.89	4.54
SD	.97	1.03	.88	.80	1.02	.98	1.11	.98	.86	1.07

Table 2. Means, standard deviations and correlations among pretest and posttest MSLQ scales and course perception variables. Minimum pairwise n = 447. Correlations with absolute values greater than or equal to .08 are significant at alpha = .05.

	Instructor Effectiveness	Course Difficulty	Collaborative Learning
Time 1 measures			
Intrinsic Goal Orientation	.20	.03	.14
Rehearsal Strategies	.16	.06	.10
Elaboration Strategies	.21	.00	.14
Metacognitive Self-Regulatory Strategies	.25	.00	.05
Critical Thinking	.13	.07	.10
Time 2 measures			
Intrinsic Goal Orientation	.40	-.07	.18
Rehearsal Strategies	.28	.08	.30
Elaboration Strategies	.36	-.07	.22
Metacognitive Self-Regulatory Strategies	.32	-.09	.16
Critical Thinking	.21	.01	.13
Mean	5.50	2.42	4.17
SD	1.00	1.11	1.71

Table 3. Discipline differences. Means with different subscripts are significantly different from one another at alpha = .05 (post hoc Scheffe tests).

	Biology	English	Social Science	F	p
Time 1 measures					
Intrinsic Goal Orientation	5.55_a	5.19_b	5.23_b	$F(2,681) = 7.86$	.000
Rehearsal Strategies	5.32_a	4.92_b	5.12_{ab}	$F(2,677) = 5.07$	.007
Elaboration Strategies	5.04_a	4.80_{ab}	4.83_b	$F(2,678) = 4.31$	.014
Metacognitive Self-Regulatory Strategies	5.01_a	4.98_a	4.76_b	$F(2,678) = 7.31$	.001
Critical Thinking	4.74	4.74	4.68	$F(2,678) = .26$	.774
Time 2 measures					
Intrinsic Goal Orientation	5.36_a	5.17_{ab}	5.02_b	$F(2,456) = 5.69$	.004
Rehearsal Strategies	5.46_a	4.45_b	4.98_c	$F(2,448) = 25.26$	.000
Elaboration Strategies	5.00_a	4.78_{ab}	4.68_b	$F(2,447) = 4.56$	.011
Metacognitive Self-Regulatory Strategies	5.08_a	4.90_{ab}	4.76_b	$F(2,450) = 4.64$	.002
Critical Thinking	4.60_{ab}	4.81_a	4.38_b	$F(2,447) = 5.98$	.005
Classroom perceptions					
Instructor Effectiveness	5.32_a	5.15_b	5.42_{ab}	$F(2,452) = 14.73$	.000
Course Difficulty	2.82_a	2.31_b	2.18_b	$F(2,453) = 16.36$	.000
Collaborative Learning	5.30_a	2.99_b	3.83_c	$F(2,454) = 78.99$	.000

Table 4. Multiple regression results, with pretest critical thinking as the outcome variable. Standardized regression coefficients are presented. Minimum pairwise ns are as follows: entire sample, 679; biology, 180; English, 94; social science, 405.

Note: + = $p < .10$ * = $p < .05$ ** = $p < .01$ *** = $p < .001$

	Entire sample	Biology	English	Social Science
Time 1 measures				
Intrinsic Goal Orientation	.33***	.23***	.19+	.22***
Rehearsal Strategies	-.03	-.10+	.18+	-.02
Elaboration Strategies	.27***	.34***	.12	.25***
Metacognitive Self-Regulatory Strategies	.33***	.27**	.28*	.35***
Discipline variables				
Biology (0 = no, 1 = yes)	-.08**			
English (0 = no, 1 =yes)	-.01			
R-squared	.45***	.46***	.38***	.47***

Table 5. Multiple regression results, with posttest critical thinking as the outcome variable. Standardized regression coefficients are presented. Minimum pairwise ns are as follows: entire sample, 447; biology, 147; English, 84; social science, 213.

Note: + = $p < .10$ * = $p < .05$ ** = $p < .01$ *** = $p < .001$

	Entire sample	Biology	English	Social Science
Time 2 measures				
Intrinsic Goal Orientation	.25***	.30***	.04	.28***
Rehearsal Strategies	-.06+	-.19**	-.02	.01
Elaboration Strategies	.28***	.27**	.15	.34***
Metacognitive Self-Regulatory Strategies	.35***	.32***	.56***	.30***
Classroom Perceptions				
Instructor Effectiveness	.05	-.04	.08	-.07
Course Difficulty	.10**	.08	.02	.14**
Collaborative Learning	.05	.10	.01	.01
Discipline variables				
Biology (0 = no, 1 = yes)	-.08*			
English (0 = no, 1 =yes)	.10**			
R-squared	.54***	.51***	.52***	.59***

Table 6. Multiple regression results, with posttest critical thinking as the outcome variable. Standardized regression coefficients are presented. Minimum pairwise ns are as follows: entire sample, 337; biology, 111; English, 71; social science, 193.

Note: + = $p < .10$ * = $p < .05$ ** = $p < .01$ *** = $p < .001$

	Entire sample	Biology	English	Social Science
Time 1 measures				
Intrinsic Goal Orientation	.17**	.37***	-.10	.11+
Rehearsal Strategies	-.11*	-.18*	.00	-.10
Elaboration Strategies	.13*	-.05	.00	.27***
Metacognitive Self-Regulatory Strategies	.38***	.40***	.38*	.38***
Classroom Perceptions				
Instructor Effectiveness	.09+	.12	.24+	.02
Course Difficulty	.04	-.02	-.04	.09
Collaborative Learning	.13**	.18*	-.05	.10+
Discipline variables				
Biology (0 = no, 1 = yes)	-.08+			
English (0 = no, 1 =yes)	.14**			
R-squared	.35****	.45***	.23*	.42***