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Disciplinary Differences in Self-Regulated Learning in College Students

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The personal attributes of self-regulated learning are often described in terms of knowledge base, adaptive motivational beliefs, and appropriate use of cognitive and metacognitive strategies for learning. These attributes are usually assumed to apply across all disciplines and contexts, but there has been little research that has examined the disciplinary differences in these personal attributes of self-regulated learning. The present study examined college students' knowledge, motivation, and self-regulatory learning strategies in humanities, social science, and natural science college courses. The sample included 380 college students from three different institutions. Students were given a measure of their course knowledge and a self-report measure of their motivational beliefs and use of self-regulatory strategies at the beginning and end of the semester. Three levels of achievement were created from final course grade and ANOVA's were used to examine the differences in knowledge, motivation, and self-regulation by achievement level and discipline. The results suggest that the components of knowledge, motivation, and self-regulation do distinguish high from low achievers in social and natural science courses, but not in the humanities courses. Results are discussed in terms of the generalizability of our models of self-regulated learning across disciplines and implications for measuring self-regulated learning in different disciplines.

Self-regulated learning is an important aspect of student academic performance in the classroom. Although there are variations in the definition of self-regulated learning, most models assume that self-regulated learners engage in the use of both cognitive and metacognitive strategies for learning as well as endorse adaptive motivational beliefs (Pintrich & De Groot, 1990; Pressley, Borkowski, & Schneider, 1989; Zimmerman, 1989, 1994). Cognitive strategies include the use of various rehearsal, elaboration, and organizational

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strategies that help students encode, recall, and comprehend information. The use of these strategies reflects a deeper level of cognitive engagement and usually results in better academic performance (Weinstein & Mayer, 1986). Metacognitive strategies for learning include planning (i.e., setting goals), monitoring (i.e., assessing comprehension while reading), and regulating (i.e., adjusting reading rate for text difficulty) and are linked to better academic performance (e.g., Pintrich & De Groot, 1990; Zimmerman & Martinez-Pons, 1986, 1988). These cognitive and metacognitive strategies represent one aspect of self-regulated learning that will be examined in this study.

There are a number of motivational beliefs that can be adaptive but three that seem particularly important are intrinsic orientation, self-efficacy, and task value. Intrinsic orientation, which involves a focus on learning and mastery, not grades or performance, has been linked to better strategy use and performance (Ames, 1992). Students' judgments of their capability to learn, self-efficacy, is also positively related to strategy use and academic performance (Schunk, 1991). Finally, task value beliefs that involve students' perceptions of the importance, utility, and interest of the task have been related to both strategy use (Pintrich & De Groot, 1990; Schiefele, 1991) and actual achievement (Wigfield & Eccles, 1992). These three motivational beliefs represent the motivational components of self-regulated learning in this study.

Besides strategy use and motivational beliefs, some models of self-regulated learning include the students' knowledge base (e.g., Pressley, Borkowski, & Schneider, 1989). There is a wealth of research that shows that students' domain-specific knowledge influences academic learning and performance (Alexander & Judy, 1988; Alexander, Kulikowich, & Jetton, 1994). In this study we have conceptualized student domain-specific knowledge in terms of organization and similarity. Organization refers to the amount of structure the students impose on the course concepts. Similarity refers to the degree to which this structure matches an expert's organization, in this case, the instructor of the course (Naveh-Benjamin, McKeachie, Lin, & Tucker, 1986). Previous research has shown that these measures are related to students' academic performance in the course in terms of exams and papers as well as overall grade (Naveh-Benjamin & Lin, 1994; Naveh-Benjamin *et al.*, 1986).

Although this model of self-regulating learning that includes knowledge, strategies, and motivation can be derived from previous research, there are very few studies that have examined all three components at the same time. For example, Zimmerman and Martinez-Pons (1986, 1988) have shown that high-achieving students use a variety of cognitive (rehearsing, memorizing, organizing, transforming) and metacognitive regulatory strategies (goal setting, planning, monitoring, self-evaluation) in contrast to low-achieving students. Pintrich and De Groot (1990) have shown that these cognitive and metacognitive strategies are positively linked to adaptive motivational beliefs such as an intrinsic orientation, high efficacy, and high value and interest.

However, these studies, which are based in the tradition of identifying the personal attributes of self-regulated learners (Zimmerman, 1994), have not included domain-specific knowledge. In contrast, studies of domain-specific knowledge have focused on domain- and discipline-specific knowledge, but they have not usually included self-regulatory strategies or motivational beliefs except for interest (Alexander & Judy, 1988; Alexander *et al.*, 1994; Tobias, 1994). Moreover, there is disagreement in the literature about the relative role of strategy use and domain-specific knowledge in academic performance. Some researchers argue that domain-specific differences have a much greater influence than strategies (e.g., Schneider, 1993). Others argue that both strategies and knowledge are important (e.g., Alexander, 1992, in press; Peverly, 1991; Pressley *et al.*, 1989). However, most studies have not included measures of both strategies and domain-specific knowledge, let alone motivation. Thus, it is difficult to make inferences about the roles these components play.

Accordingly, one purpose of this study is to include measures of all three of these important components—knowledge, motivational beliefs, and cognitive strategies—to see how they relate to student academic performance. The basic strategy is to examine how students at different academic performance levels differ in their knowledge, motivation, and self-regulated learning (e.g., Zimmerman & Martinez-Pons, 1986). This strategy of describing the personal attributes of self-regulated learners has been an important contribution to research on self-regulated learning (Zimmerman, 1994). The inclusion of how measures of knowledge, motivation, and self-regulatory strategies in one study will extend our description of the personal attributes of a self-regulated learner and help to clarify the role of knowledge, strategies, and motivation in academic performance.

At the same time, as Schunk and Zimmerman (1994) point out, there is a need for more research on how self-regulated learning is affected by situational influences. Most models of self-regulated learning assume that the positive relations between domain-specific knowledge, adaptive motivational beliefs, and use of cognitive and metacognitive strategies with academic achievement and performance will be similar across situations and contexts. However, there may be variations in the relative importance of different personal attributes depending on the context. For example, Howard-Rose and Winne (1993) suggest that the nature of the tasks students are asked to complete can influence the level of self-regulated learning. Pintrich, Roeser, and De Groot (1994) found that both initial individual differences in self-regulated learning and aspects of the classroom context (e.g., teacher behavior, nature of tasks) were related to later levels of self-regulated learning.

There also may be another level of context that is important beyond variation in tasks and teachers, specifically, the academic discipline. Blumenfeld (1992) has suggested that disciplinary differences in the content areas may have implications for students' motivational orientations. Stodolsky and colleagues (e.g., Grossman & Stodolsky; Stodolsky, 1988; Stodolsky, Salk, & Glaessner, 1991) have shown that the nature of instruction and tasks were different in elementary math and social studies and that students' perceptions of instruction and their task value beliefs varied as a function of these disciplinary differences. They have also shown that secondary school teachers' beliefs vary by discipline. Further work by Donald (1990, 1994) has found differences in professors' beliefs about the nature of knowledge and learning in their disciplines, and about how knowledge is validated in different disciplines. Interviewing humanities, social science, and natural science professors, she found that the greatest variance of responses to the question of how knowledge is validated in their discipline came from humanities professors, and the smallest variance of responses came from natural scientists. Natural and social scientists also placed a greater importance on empirical validation, and humanities professors placed a greater importance on validation through external authority such as peers' judgments of plausibility.

Given the work by Stodolsky and her colleagues in K–12 settings and Donald's work at the college level, it appears that instructors' beliefs about learning and teaching do differ by discipline. In addition, these beliefs seem to translate into differences in instructional activities by discipline. However, very little of this research has examined how these disciplinary differences may be related to the pattern of students' motivation and cognition. Following Donald's lead, we included humanities (English), social science (psychology and sociology), and natural science (biology) courses in order to examine differences across a diverse spectrum of disciplines. Our study investigated disciplinary differences in the importance of the various personal attributes of a self-regulated learner including knowledge, motivation, and self-regulatory strategies.

In summary, the first purpose of the study was to include a wider range of personal attributes of a self-regulated learner than previous studies. Using the approach adopted by Zimmerman and Martinez-Pons (1986, 1988), we will examine how students' knowledge, motivational beliefs, and cognitive strategies differ as a function of achievement. We expected that high-achieving students would have a better knowledge base, have more adaptive motivational beliefs, and report more use of self-regulatory cognitive and metacognitive strategies than low-achieving students. The second purpose concerned the generalizability of this pattern of knowledge, motivation, and self-regulation across three different disciplines of English, psychology, and biology.

METHOD

Subjects

Subjects were undergraduates from three different colleges. One was a comprehensive public university; one was a 2-year community college; and one was a 4-year, private, liberal arts college. A total of 380 students participated in the study (males = 152, 40%; females = 222, 58%; 6 subjects did not report their gender); 90 students attended the public university, 161 attended the community college, and 129 attended the liberal arts college. One hundred forty-five were enrolled in natural science courses, 151 in social science courses, and 84 in humanities courses.[1] Over 90% of the students were white and this distribution was fairly consistent across the three colleges.

Students were sampled from nine different introductory level courses, three courses from each school with one social science, one humanities, and one natural science course from each school. Three of the courses were social science courses (psychology and sociology), three of the courses were humanities (English composition and literature), and three of the courses were natural science (introductory biology and general ecology). The courses were fairly traditional lecture/discussion courses that ranged from 15 to 77 students. All courses had a mix of midterm and final exams as well as papers (lab reports in biology) to assess student performance, but the English courses did not have multiple-choice exams (only essay or short answer questions), whereas all the natural and social science exams used both multiple-choice and essay questions.

Materials

Students' knowledge for the course material was assessed by using the ordered-tree technique developed by Naveh-Benjamin, McKeachie, Lin, and Tucker (1986). This technique asked the students to sort concepts from the course over four trials based on the assumption that students would sort concepts they see as related into chunks. The technique capitalizes on individuals' tendency to list or sort all items in one chunk of memory before moving onto the next chunk (Naveh-Benjamin & Lin, 1994). For each course, instructors identified a list of 15–20 concepts that reflected the important concepts from the major content areas covered in the course. These concepts were then listed alphabetically in columns on the left side of each page in a test booklet with four pages (one page for each of the four trials). Previous research (Naveh-Benjamin *et al.*, 1986) has shown that four sorting trials are sufficient to provide reliable estimates of students' knowledge structures. On the first sorting trial, a cued trial, students are asked to start their sort (i.e., list) with one of the concepts from the list on the left side of the page. On the right side of the page is a column of blank lines with the first line filled in with the cued concept. They are asked to place on the second line the concept that is closest in meaning to this cued concept. On the third line they are asked to place the concept that is closest in meaning to the concept

[1] By sampling one discipline type from each institution type, we attempted to eliminate any discipline-by-institution confound. However, we could not control the enrollment in the classes. The discipline-by-institution cell sizes are as follows: The liberal arts college had 17 in humanities, 35 in social science, and 77 in natural science; the public university had 30 in humanities, 45 in social science, and 15 in natural science; the community college had 37 in humanities, 71 in social science, and 53 in natural science. Although the percentage of students in each of the disciplines is not the same for each institution, there is no systematic pattern to this difference. For example, no institution had either the largest or the smallest class sizes. As far as disciplines are concerned, it was also not the case that one division always had either the smallest or the largest classes. For example, although humanities had the smallest overall number of students, it is not the case that the humanities classes were always the smallest classes. In fact, humanities was only the smallest at the liberal arts school; it was middle-sized at the community college and public university. Therefore, although an interaction of class size with institution could affect the constructs we measured, we see no consistent pattern that would predict a confound.

they placed on the second line. This sorting continues until all the concepts are used. The second trial is an uncued trial because the students are told to start their list with any concept they choose. The third trial is a cued trial with a different concept used (than that used on the first trial) as the cue. The fourth and last trial is an uncued trial. The test booklet is done during class time and after each trial the instructor lectures or presents some information to allow for a break between trials. The students are asked not to look back at their sorts from previous trials.

These four sorts are then entered into a computer algorithm developed by Reitman and Rueter (1980) that examines the different ordering of the concepts over the four trials to identify the chunks or nodes generated by the ordering of the concepts. Two measures were generated from this algorithmic analysis of the sorts—*similarity* and *organization.* Similarity provided an index of the similarity of the student's tree to the instructor's tree (for each course the instructor also did the task). A high score on this similarity measure indicates that the student's organization of the course concepts is similar to the instructor's organization of the concepts. The other measure, organization, is the natural logarithm of the number of different written orders that could contain the chunks or nodes in a student's response. A smaller number on this measure is reflective of more conceptual coherence and organization (more of the same nodes emerged over the trials) and a high number represents less organization (more different nodes emerged over the trials). Accordingly, for ease of reading, in our tables we have referred to this measure as disorganization.

Students' motivational beliefs and self-regulated learning were assessed with the Motivated Strategies for Learning Questionnaire (henceforth referred to as MSLQ; Pintrich, Smith, Garcia, & McKeachie, 1993). The general instructions for the MSLQ asked the students to respond in terms of their beliefs and behavior for the specific course they were enrolled in and all items were worded to stress this course specificity (e.g., ''In this course . . .'', ''When I study for this course . . .''). Three motivational beliefs were assessed on the MSLQ: *intrinsic orientation* (4 items, pretest alpha for this sample = .60, post-test alpha = .66), which reflects the students' orientation to the class in terms of learning and mastery; *task value* (9 items, alpha's = .92, .94), which assessed students' interest level in the course material and their judgments of the importance and utility of course material to them; *self-efficacy* (5 items, alpha's = .75, .81), regarding their confidence in their ability to learn the course material.

Four cognitive strategy scales were generated from the MSLQ. The *rehearsal* scale (6 items, alpha's = .50, .52) assessed use of rote memory strategies. The *elaboration* scale (11 items, alpha's = .79, .82) asked students to report on their use of summarizing, paraphrasing, and selecting important ideas from the course material. The *organization* scale (5 items, alpha's = .67, .61) tapped students' use of self-made outlines, charts, cognitive maps, or graphs for organizing the course material. Finally, use of planning (setting study goals), comprehension monitoring, and regulating (adjusting reading rate for difficulty of text) strategies were combined into one scale, *metacognition* (13 items, alpha's = .80, .80).

Procedure

Subjects completed the ordered-tree exercise at the beginning and the end of the semester during class time. Before the course began, the instructors generated a list of concepts and an ordered-tree for the course that was used as the criterion to judge similarity. Students also filled out the MSLQ at the beginning and at the end of the semester during class time. Final course grades were collected at the end of the semester from the instructors.

RESULTS

We performed one-way analyses of variance (ANOVA's) on the variables from the MSLQ and the ordered-tree. We split the students into three groups based on their final course grade within each of the disciplines in order to control for differences in grading distributions. Final grades ranged from 0.0 (*F*) to 4.0 (*A*). For natural science and social science, high achievers were those 3.3 and above (n's = 60 and 36 for natural science and social science, respectively), medium achievers were those between 2.5 and 3.0 inclusive (n's = 52 and 59 for natural science and social science, respectively), and low achievers were those 2.3 and below (n's = 43 and 56 for natural science and social science, respectively). For humanities, high achievers were those 3.5 and above ($n = 36$), medium achievers were those between 2.7 and 3.3 inclusive ($n = 31$), and low achievers were those 2.3 and below ($n = 17$).

The dependent variables were ordered-tree similarity, ordered-tree disorganization, intrinsic orientation, task value, self-efficacy, rehearsal, elaboration, organization, and metacognition. We performed the analyses separately for the three divisions of natural science, social science, and humanities. We performed the analyses on both the beginning-of-semester and end-of-semester scores. All significant F's ($p < .05$) were followed by Fisher's LSD test.

Natural Science

Table 1 gives the means for the three levels of achievement on the dependent variables for the natural science courses. Nine MSLQ variables were significantly different as a function of final grade. Self-efficacy was significantly different among the three groups at both the beginning and the end of the semester, $F(2,135) = 12.2$, $p < .0001$; $F(2,128) = 25.1$, $p < .0001$, respectively. Fisher's LSD tests indicated that, at the beginning of the semester, high and medium final-grade students had significantly higher self-efficacy scores than low final-grade students. At the end of the semester, high final-grade students had higher self-efficacy scores than medium final-grade students, who were higher than low final-grade students. A significant difference was also found in task value scores at the end of the semester, $F(2,128) = 6.32$, $p < .01$. Fisher's LSD tests indicated that low final-grade students had lower task value scores than high and medium final-grade students, who did not differ from each other. (The F ratio for beginning-of-semester scores on task value was marginally significant, $p < .06$.)

All four cognitive strategy variables were significantly different among the three groups. Two were significant at both the beginning of the semester and the end of the semester—organization and metacognition. A significant difference was found in organization scores at both the beginning and the end of the semester, $F(2,135) = 8.73$, $p < .001$; $F(2,128) = 11.4$, $p < .0001$, respectively. Fisher's LSD tests indicated that, at both the beginning and the end of the semester, high final-grade students had significantly higher organization scores than medium and low final-grade students, who did not differ from each other.

A significant difference was also found in metacognition scores at both the beginning and the end of the semester, $F(2,135) = 3.71$, $p < .05$; $F(2,128)$

TABLE 1
MEAN SCORES ON DEPENDENT VARIABLES FOR STUDENTS IN NATURAL SCIENCE COURSES

	Final grade			
Variable	Low	Middle	High	F
Ordered-tree measures				
Similarity 1	.21	.30	.32	2.59
Similarity 2	$.32_a$	$.43_b$	$.45_b$	4.64*
Disorganization 1	28.2	23.6	23.1	1.53
Disorganization 2	23.6	18.4	18.1	2.25
MSLQ measures				
Intrinsic 1	5.23	5.42	5.73	2.04
Intrinsic 2	5.59	5.44	5.74	1.55
Self-efficacy 1	4.83_a	5.11_a	5.72_b	12.24****
Self-efficacy 2	4.37_a	4.99_b	5.82_c	25.06****
Task value 1	5.76	6.00	6.22	2.94
Task value 2	5.34_a	5.85_b	6.16_b	6.32**
Organization 1	5.01_a	5.16_a	5.70_b	8.73***
Organization 2	4.86_a	5.01_a	5.66_b	11.40****
Rehearsal 1	4.50	4.68	4.84	1.56
Rehearsal 2	4.32_a	4.69_{ab}	5.03_b	6.85**
Elaboration 1	3.81_a	3.81_a	4.33_b	6.15**
Elaboration 2	4.04	4.16	4.34	.98
Metacognition 1	4.68_{ab}	4.58_a	4.95_b	3.71*
Metacognition 2	4.73_a	4.82_a	5.18_b	4.53*

Note. Variables with ‘‘1’’ are pretest; variables with ‘‘2’’ are post-test. Variables printed in bold indicate they were significantly different by final grade. *$p < .05$, **$p < .01$, ***$p < .001$, ****$p < .0001$. Different subscripts next to the means indicate that the groups are significantly different by Fisher’s LSD procedure.

= 4.53, $p < .05$, respectively. Fisher’s LSD tests indicated that, at the end of the semester, high final-grade students had significantly higher metacognition scores than medium and low final-grade students, who did not differ from each other. Curiously, at the beginning of the semester, the lowest metacognition score was for the medium final-grade group, which was significantly lower than the high final-grade group. The low final-grade group had the middle score and did not differ from either of the other two groups.

A significant difference was found in rehearsal scores at the end of the semester, $F(2,128) = 6.85$, $p < .005$. Fisher’s LSD test indicated that high final-grade students had higher rehearsal scores than low final-grade students, and that medium final-grade students did not differ from the other two groups.

A significant difference was found in elaboration scores, but only at the

TABLE 2
MEAN SCORES ON DEPENDENT VARIABLES FOR STUDENTS IN SOCIAL SCIENCE COURSES

Variable	Final grade Low	Middle	High	*F*
		Ordered-tree measures		
Similarity 1	$.11_a$	$.20_b$	$.27_b$	6.45**
Similarity 2	$.29_a$	$.40_b$	$.50_b$	7.08**
Disorganization 1	31.1_a	24.2_b	23.6_b	4.15*
Disorganization 2	24.9_a	19.7_b	15.5_b	6.50**
		MSLQ measures		
Intrinsic 1	5.46	5.51	5.82	1.20
Intrinsic 2	5.40	5.59	5.73	1.13
Self-efficacy 1	4.62_a	5.01_{ab}	5.25_b	3.76*
Self-efficacy 2	4.51_a	5.20_b	5.22_b	6.79**
Task value 1	5.89	6.01	5.86	.23
Task value 2	5.50_a	6.12_b	5.75_{ab}	4.17*
Organization 1	5.06_a	5.38_b	5.55_b	3.82*
Organization 2	4.87_a	5.45_b	5.32_{ab}	4.71*
Rehearsal 1	4.23_a	4.59_{ab}	4.82_b	3.32*
Rehearsal 2	4.30_a	4.67_b	4.83_b	3.84*
Elaboration 1	4.03	3.95	4.01	.09
Elaboration 2	4.12	3.84	3.72	1.26
Metacognition 1	4.74	4.80	5.08	1.56
Metacognition 2	4.69	4.71	4.62	.26

Note. Variables with ''1'' are pretest; variable with ''2'' are post-test. Variables printed in bold indicate they were significantly different by final grade. $*p < .05$, $**p < .01$, $***p < .001$, $****p < .0001$. Different subscripts next to the means indicate that the groups are significantly different by Fisher's LSD procedure.

beginning of the semester, $F(2,135) = 6.15$, $p < .005$. Fisher's LSD test indicated that high final-grade students had significantly higher elaboration scores than low and medium final-grade students, who did not differ from each other.

One ordered-tree measure—post-test similarity—was significant for natural science, $F(2,113) = 4.64$, $p < .05$. Fisher's LSD test indicated that high and medium final-grade students had higher similarity scores than low final-grade students (recall that greater similarity scores reflect greater agreement with the professor's representation of course material).

Social Science

Table 2 gives the means for the three levels of achievement on the dependent variables for the social science courses. Seven MSLQ variables were significantly different as a function of final grade. With respect to motivational variables, just as for natural science courses, a significant difference was found in self-efficacy scores at both the beginning and the end of the semester, $F(2,92) = 3.76$, $p < .05$; $F(2,93) = 6.79$, $p < .01$, respectively. Fisher's LSD test of the beginning-of-semester scores indicated that high final-grade students had higher self-efficacy scores than low final-grade students, and that the medium final-grade scores did not differ from either the high or low groups. Fisher's LSD test of the end-of-semester scores indicated that low final-grade students had lower self-efficacy scores than medium and high final-grade students, who did not differ from each other. Also, a significant difference for task value scores was found among the three groups, but only for the end of the semester, $F(2,93) = 4.17$, $p < .05$. Fisher's LSD test indicated that medium final-grade students had higher task value scores than low final-grade students, and that high final-grade scores were in the middle, not differing from the other two groups.

With respect to cognitive strategy variables, a significant difference was found for organization scores at both the beginning and the end of the semester, $F(2,92) = 3.82$, $p < .05$; $F(2,93) = 4.71$, $p < 05$, respectively. Fisher's LSD test of the beginning-of-semester scores indicated that high and medium final-grade students had higher organization scores than low final-grade students. At the end of the semester, medium final-grade students had higher organization scores than low final-grade students, and the high final-grade group was in the middle, not differing from the other two.

Also, a significant difference for rehearsal was found among the three groups at both the beginning and the end of the semester, $F(2,92) = 3.32$, $p < .05$; $F(2,92) = 3.84$, $p < .05$, respectively. Fisher's LSD test at the beginning of the semester indicated that high final-grade students had higher rehearsal scores than low final-grade students, and that the medium final-grade group was in the middle, not differing from either of the other groups. At the end of the semester, high and medium final-grade students had higher rehearsal scores than low final-grade students.

In addition to the seven MSLQ variables, both ordered-tree measures at both the beginning and the end of the semester were significantly different as a function of final grade. A significant difference was found for similarity scores at both the beginning and the end of the semester, $F(2,114) = 6.45$, $p < .01$; $F(2,125) = 7.08$, $p < .01$, respectively. Fisher's LSD test indicated that, for both the beginning and the end of the semester, high and medium final-grade students had higher similarity scores (i.e., ordered-trees that were more similar to that of their instructor's) than low final-grade students. A significant difference was found for disorganization scores at both the beginning and the end of the semester, $F(2,114) = 4.15$, $p < .05$; $F(2,125) = 6.50$, $p < .01$, respectively. Fisher's LSD test indicated that, for both the beginning and the end of the semester, low final-grade students had higher disorganiza-

TABLE 3
MEAN SCORES ON DEPENDENT VARIABLES FOR STUDENTS IN HUMANITIES COURSES

Variable	Final grade Low	Middle	High	*F*
		Ordered-tree measures		
Similarity 1	.24	.32	.24	1.15
Similarity 2	$.50_a$	$.32_b$	$.31_b$	3.64*
Disorganization 1	28.69	24.26	24.91	.54
Disorganization 2	20.23	23.12	24.17	.41
		MSLQ measures		
Intrinsic 1	5.25	5.38	5.44	.27
Intrinsic 2	4.96	5.31	5.67	2.87
Self-efficacy 1	4.99	5.01	5.12	.18
Self-efficacy 2	4.44_a	4.79_a	5.43_b	8.55***
Task value 1	5.02	5.18	5.44	1.00
Task value 2	4.60	4.91	5.43	2.84
Organization 1	5.10	4.90	5.28	1.87
Organization 2	4.71_a	4.80_a	5.32_b	4.25*
Rehearsal 1	4.74	4.76	4.65	.19
Rehearsal 2	4.31	4.62	4.61	.71
Elaboration 1	3.93	3.62	3.91	1.19
Elaboration 2	3.96	3.75	3.91	.41
Metacognition 1	4.53	4.53	4.71	.43
Metacognition 2	4.45	4.51	4.63	.27

Note. Variables with ''1'' are pretest; variables with ''2'' are post-test. Variables printed in bold indicate they were significantly different by final grade. $*p < .05$, $**p < .01$, $***p < .001$, $****p < .0001$. Different subscripts next to the means indicate that the groups are significantly different by Fisher's LSD procedure.

tion scores than medium and high final-grade students, who did not differ from each other.

Humanities

Table 3 gives the means for the three levels of achievement on the dependent variables for the humanities courses. Only two MSLQ variables were significantly different as a function of final grade. One motivation measure—self-efficacy—was significantly different as a function of final grade, but only at the end of the semester, $F(2,68) = 8.55$, $p < .001$. Fisher's LSD test indicated that high final-grade students had higher self-efficacy scores than medium and low final-grade students, who did not differ from each other.

One cognitive strategy measure—organization—was significantly different as a function of final grade, but only at the end of the semester, $F(2,68) = 4.25$, $p < .05$. Fisher's LSD indicated that high final-grade students had higher organization scores than medium and low final-grade students, who did not differ from each other.

One ordered-tree measure—end-of-semester similarity—was significant as a function of final grade, $F(2,64) = 3.64$, $p < .05$. Curiously, Fisher's LSD test indicated that low final-grade students had *higher* similarity scores (i.e., ordered-trees that were more similar to that of their instructor's) than medium and high final-grade students. This is in contrast to the direction of the effect for the other two disciplines.[2]

DISCUSSION

In terms of the first general purpose of this paper, our understanding of the important personal attributes of a self-regulated learner—motivational beliefs, cognitive strategies, and domain-specific knowledge—has been extended by examining how these variables differ as a function of academic performance differences. Students who did well in the course were more likely to have adaptive motivational beliefs and particularly high efficacy and task value beliefs, as well as report more use of cognitive and metacognitive strategies. Better levels of domain-specific knowledge were important, but only for students in the social science courses. Accordingly, contrary to Schneider (1999) and in line with Alexander (1992, in press) and Peverly (1991) both domain-specific knowledge and strategy use are important for academic performance. Moreover, in line with general approaches to self-regulated learning (Pintrich & DeGroot, 1990; Zimmerman, 1994), we found adaptive motivational beliefs to be predictive of academic performance, but most clearly in natural and social sciences. However, we found these relationships differed as a function of academic discipline.

This study of disciplinary differences was the second general purpose of our study. The greatest number of significant differences in motivation and strategy use by performance level occurred for students in the natural science

[2] We did find that final grade did differ as a function of discipline, $F(2,377) = 8.82$, $p = .002$, with humanities grades being higher than natural and social science. To ensure that these findings were not an artifact of grading differences, we also divided the students into achievement groups relative to other students in that same discipline. We defined the top quartile as high achievers, the middle two quartiles as medium achievers, and the bottom quartile as low achievers. When we did this, we found almost identical results. All of the effects that were nonsignificant remained nonsignificant for all three divisions. One dependent measure for natural science (pretest MSLQ metacognition) and for humanities (post-test MSLQ organization) was nonsignificant, and two dependent measures for social science (pretest ordered-tree disorganization and pretest MSLQ organization) were nonsignificant when the groups were created in this way. All the other effects were the same.

courses, in which nine variables were significantly different as a function of performance level. Students in social science courses showed seven significant differences and students in the humanities showed only two significant differences in motivation and self-regulatory strategy use by performance level. We explore these differences in more detail below, first by discussing differences in cognitive strategy use, then differences in motivational variables, and then differences in the knowledge variables.

What might account for the disciplinary differences in how well cognitive strategies predict achievement? One explanation is in terms of the different cognitive demands each discipline presents (Doyle, 1983). For example, for the six cognitive strategy variables (pretest and post-test elaboration, rehearsal, and organization) four of these were significant for natural and social science courses, with high achievers using more of these strategies in comparison to low achievers. However, in humanities, only one of these variables was significant. Assignments in the natural and social sciences used multiple-choice examinations, which required students to access specific course content knowledge. Knowledge that is better rehearsed, elaborated, and organized will be easier to access at test time. Therefore, these cognitive strategies will likely correlate positively with such objective measures of comprehension. Therefore, it makes sense that use of these strategies correlates with achievement in natural science and social science. Humanities courses, on the other hand, did not contain multiple-choice tests, but rather required essay tests, papers, and take-home examinations. Extensive rehearsal of course information, for example, usually will not improve performance on these kinds of assessment. Of course, one limitation of this study is that the nature of the tasks is confounded with discipline since there were no humanities classes that used multiple-choice exams. Future research should avoid this confounding and this will help disentangle contextual effects that emerge from the discipline from those due to the nature of the tasks (Pintrich, 1994).

What might account for the disciplinary differences in how well the motivational variables predict achievement? First, with respect to self-efficacy, end-of-semester self-efficacy scores related to achievement level in all three disciplines, with high achievers having higher self-efficacy beliefs. This is consistent with previous research (Pintrich, 1989; Schunk, 1991). By the end of semester, students have received a fair amount of feedback on their course performance, so their judgments of self-efficacy are well calibrated to their actual level of performance. It is interesting to note that for both natural and social science courses, beginning-of-semester self-efficacy scores also related to final grade in the same fashion as end-of-semester self-efficacy. Given that the social and natural science courses were more traditional in terms of the way course material was presented (i.e., lecture), types of knowledge presented (i.e., facts and definitions), and types of assessment techniques used (i.e., objective tests), it may have been easier for students to make relatively accurate judgments of efficacy. On the other hand, given that the humanities courses used different types of course presentation (e.g., discussion, small groups), presented different types of knowledge (e.g., broad themes, focus on procedures for writing), and used different assessment techniques (e.g., essays, take-home exams, reaction papers), then students' initial judgments of their efficacy at the beginning of the term may not relate as well to later performance.

Second, with respect to task value, high achievers in both the natural and the social science courses also had higher levels of task value at the end of the term, but this did not hold in the humanities courses. High achievers reported more interest, importance, and utility for the course material than low achievers in natural and social science courses, paralleling previous research (Pintrich & De Groot, 1990; Pintrich *et al.,* 1993). Overall levels of task value were somewhat lower in the humanities courses, perhaps reflecting the fact that introductory level college English courses are often required courses that generate little interest or value from the students. It also is interesting to note that intrinsic orientation was not significantly different among the three levels of performance for any of the divisions at either the beginning or the end of the semester, which is not reflective of previous research (cf. Ames, 1992). It may be that mastery orientation may not play as strong a role in differentiating performance in college classrooms as it does in K–12 education, given that students have a choice about attending college. Given the self-selection in college attendance, it may be that all students are relatively high in mastery orientation (as suggested by the overall means in this study), but further research with more diverse samples is necessary to evaluate this hypothesis.

What might explain the differences we found in knowledge variables? Recall that our first finding was that students in social science courses showed post-test differences on all four ordered-tree measures. These differences were in the expected direction, with high achievers showing the greatest similarity to the instructor's ordered-tree and the least amount of disorganization. Our second finding was that post-test similarity was also significant for humanities and natural science, but the other three were not. The direction of the difference in post-test similarity was in the expected direction and the same as that for social science. However, the effect for humanities was in the *opposite* direction to the other two disciplines; the low achievers had higher similarity scores. This suggests that having a representation similar to that of the instructor is not necessary for high academic achievement in humanities courses. Given that the humanities professors reported having trouble completing the ordered-tree exercises suggests that experts in the field view domain knowledge in humanities as being contained in different representations or subject to multiple interpretations. This finding provides us with fairly convincing evidence that any knowledge measure that invokes or assumes a hierarchical knowledge representation may not be appropriate for measuring students' domain knowledge in humanities.

The fact that knowledge in the humanities courses was seen (as reported by the instructors) as less hierarchical, less structured, and more open to multiple representations would also explain why the disorganization score would not be predictive of achievement in humanities courses. A student's mental representation that has a hierarchical organization, for example, may not be very helpful in predicting how well a student may do in the course. Thus, the no-difference finding for disorganization in the humanities is not surprising.

However, the no-difference finding for the disorganization ordered-tree measure in the natural science courses is surprising. It would seem helpful to have an organized mental representation of course knowledge in natural science courses. Information such as biological classification schemes and the Periodic Table of the Elements in chemistry are examples of how, it would seem, having an organized representation of course knowledge would be necessary for success in natural science courses. However, only the students' similarity score but not the disorganization score was significantly different by final grade. Several possibilities could explain this. First, it may be that instructors do not tap the same knowledge on their course examinations as what is tapped in the ordered-tree exercise. Second, it may be that the ordered-tree measures do not require students to use important or relevant knowledge, although previous research has shown success with this technique in predicting student knowledge (e.g., Naveh-Benjamin & Lin, 1994). Third, it is probably true that final grade is not a perfectly accurate measure of what students have learned. Final grade not only includes test scores, but also may include points for activities such as class participation and in-class exercises. These latter components may not be related to a student's organized mental representation of the course material.

We were struck by the orderliness of the data for performance level differences. This was true for cognitive strategy variables, the motivational variables, and the knowledge variables. One can see by examining Tables 1–3 that almost all of the significant effects have the same pattern of differences. For all but three significant effects (post-test task value and organization for social science and pretest metacognition for natural science) there was a linear ordering of effects, with the high achievers showing the highest scores, followed by the average achievers, followed by the low-achieving group. Although the follow-up tests did not always show that each of the three groups were statistically different for each variable, the ordering of the means was the same for each of the significant effects.

The generalizability of this study is limited in several ways. First, we only sampled three institutions, although we did have a range of schools represented. Second, we only sampled three disciplines. We do not know whether the findings would hold up in other academic domains such as mathematics. Third, all of our classes were traditional in terms of being lecture/discussion oriented. We do not know what would happen to achievement differences in self-regulated learning in laboratories, small-group seminars, or other classroom settings. Fourth, our sample was mostly white, so we do not know whether these findings would generalize across racial or ethnic boundaries. Finally, future studies should include in-class observations that will allow an understanding of how differences in classroom activities may underlie the differences we found. Grossman and Stodolsky (1995) report high school teachers from different academic disciplines vary in ways such as instructional practices and beliefs about learning and content knowledge. For example, mathematics teachers believe learning in their discipline is static and linear, whereas English teachers are more likely to stress the flexibility of knowledge in the subject matter. It seems logical that such differences in teachers' beliefs will be related to differences in students' beliefs. These differences were found among secondary teachers, and it seems likely that such differences are at least as likely to be found in college instructors, who are probably even more enmeshed in their content subculture. Classroom analyses will further clarify these relationships.

We also find it interesting that the scores on our pretest measures actually preceded the attainment of final grade, which was used for determining our independent variable. This is a procedure similar to that used by Zimmerman and Martinez-Pons (1986, 1988). We find it intriguing that students differ on certain self-regulatory variables before the course even begins. It is even more interesting that these patterns of differences are not the same across different disciplines.

Taken together, these results suggest that the personal attributes of high levels of domain-specific knowledge, adaptive motivational beliefs, and use of self-regulatory strategies are good descriptors of high achievers in social science and natural science courses. Theoretically, it seems plausible to argue that models of self-regulated learning that incorporate measures of these three general components seem to apply most readily to these types of courses. However, our results suggest that, in humanities courses, our models and methods need to be adjusted to better represent the nature of learning and instruction. It may be that other strategies that we did not assess in this study, such as listening to others, contributing to class dialogue, articulating personal responses through critiques of other classmates' papers, and working well in small groups may better distinguish high and low performers in English classes. This is one direction for future research—to enlarge our definitions and models of self-regulated learning, as well as our measurement procedures, in order to better describe self-regulated learning in different disciplines and courses. In addition, the results give us pause and suggest that we not overgeneralize our models and measures of self-regulated learning until we have tested them in a variety of disciplines and classroom contexts. In this way, we will begin to set some disciplinary or domain boundary conditions for our general model of self-regulated learning which, in the long run, will help us better describe learning in specific classroom settings. Moreover, as we develop these contextualized descriptions of self-regulating learners, this information will be more applicable to instructors who are always teaching within a discipline and are constrained by the norms of that discipline.

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