Increasing Academic Performance and Retention in Undergraduate Science Students: An Achievement Motivation Intervention

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EXECUTIVE SUMMARY

Background

According to a report by the Ontario Ministry of Training, Colleges and Universities (2005) , 30 to 40% of all students enrolled in four-year degree programs drop out, and 78-80% of those who do drop out will do so in their first year. Similar levels have been reported in other provinces, such as Québec (25-35%, Montmarquette, Mahseredjian, & Houle, 2001). In a paper for the Commission of Inquiry on Canadian University Education, Gilbert (1991) estimated that after five years the non-completion rate for university undergraduates is approximately 42% across Canada. Of particular concern, research on student retention has demonstrated that some disciplines have higher drop-out rates than others; science, mathematics, and engineering students are more likely to drop out than students in other disciplines (Daempfle, 2004). Moreover, each year approximately 35% of undergraduates fail introductory mathematics and science classes (Useem, 1992). Because of these growing concerns, research is needed that focuses on increasing retention and achievement in undergraduate science. This research addresses these concerns by implementing a different approach to providing feedback to students that may result in higher achievement and increased retention at the undergraduate level of education.

Purpose

The purposes of this research were to respond to the retention issue at the undergraduate level of education. We examined whether manipulating the types of feedback that students receive decreased students' anxiety for learning, and increased their personal mastery and performance-approach goals (i.e., achievement goals), academic self-efficacy (i.e., confidence), use of learning strategies, academic achievement, and retention in the context of first-year undergraduate chemistry courses.

Research Design

Undergraduate students enrolled in two required inorganic chemistry classes participated and were assigned to one of four types of feedback conditions: mastery feedback (i.e., a focus on understanding), performance-approach feedback (e.g., a focus on doing better than others), combined mastery/performance-approach feedback, and a control group (no additional feedback beyond the reporting of raw performance scores on quizzes). Within the first week of the course, and prior to any assessments, students completed a demographics questionnaire, a prior knowledge test, and items from questionnaires designed to measure their motivation, learning strategies, and anxiety for learning the course content.

Over the course of the semester, students received weekly feedback via a computer-based program about their performance in the course. After quizzes were graded, feedback was automatically displayed upon login to the computer program to ensure students received their performance evaluation. At the end of the semester, prior to students completing the final exam, students were asked to complete the questionnaires again.

Results

Although there were no differences between the groups at the beginning of the semester, significant differences across groups were found at the end of the semester. Specifically, students that received some type of feedback beyond just their grades had higher levels of self-efficacy (confidence) at the end of the semester compared to students that received no additional feedback. For the control group, both males' and females' level of self-efficacy (confidence) dropped significantly from pretest to posttest. Moreover, students in the mastery goal and performance-approach goal conditions had significantly lower levels of anxiety at the end of the semester compared to students in the control group. In particular, male students in the control group experienced significant increases in levels of anxiety from the beginning of the semester to the end of the semester, whereas female students in the performance-approach group had significant decreases in anxiety and increases in levels of metacognitive self-regulation.

Discussion

Results from our study indicate that providing students with feedback that includes more than a raw performance score is more beneficial than a raw score alone. The positive influence that feedback has on students is consistent with predictions from contemporary models of self-regulated learning (e.g., Muis, 2007; Pintrich, 2000b; Winne & Hadwin, 1998; Zimmerman, 1998). In the context of learning, feedback serves as a source of information that individuals may use to gauge whether one has achieved his or her learning goals, or whether one must adjust goals, strategies, or motivation to better achieve those goals (Muis, 2007). This feedback can be used to judge whether the set goals have been achieved; if not, then that information may be used to adjust or redefine an individual's learning goals, types of learning strategies to use, or future motivation on subsequent similar learning tasks.

Trends in the data also suggest that receiving additional feedback increased student retention as students in the control group had the highest level of probationary status. Accordingly, we posit that providing some form of feedback that is more than a raw performance score benefits students' motivation and affect.

Educational Implications

Given the increasing demands for scientists (National Science Board, 2006) and the growing concerns of dropout rates for undergraduate students enrolled in the sciences (Daempfle, 2004), it is pertinent that educators implement classroom interventions that foster student learning, motivation, and achievement. We responded to this pressing concern by implementing a system in an online environment that manipulated the types of feedback students received on their course quizzes. Our goal was to create different learning environments that mirrored the types of classroom goal structures that researchers suggest might foster improved learning, motivation, and achievement. By creating environments that potentially increase student learning, we aimed to increase student retention in first-year undergraduate chemistry courses.

The control group, wherein students did not receive feedback on course quizzes other than a raw performance score, had higher rates of students on probationary status than the three treatment groups. To interpret this outcome, we highlight students in the treatment groups had higher self-efficacy and lower levels of anxiety at the end of the semester compared to students in the control group. Based on these results, we infer that the additional feedback students received in the treatment groups fostered students' self-efficacy and lowered their anxiety, which subsequently led to increases in student learning. This result is consistent with previous research (Biesinger et al., 2009; Muis et al., 2009; Winne et al., 2005).

Accordingly, we posit that our intervention holds great promise in addressing student retention at the undergraduate level of education. Specifically, provincially or state-funded colleges and universities in North America typically have large first-year undergraduate enrollments in the sciences and mathematics. Given the large number of students in these courses, it is particularly challenging for professors to provide immediate feedback and feedback that provides more than raw score information. In a time of budget cuts and reductions in teaching assistantships, professors are left to grapple with large amounts of grading and little time to complete it. By implementing a system that provides students immediate feedback on their performance coupled with information that focuses on understanding and improvement, comparative performance, or both, there is more opportunity for students to learn from that immediate feedback, which may subsequently improve student outcomes (Muis, 2007; Winne & Hadwin, 1998).

Abstract

The purpose of this research was to examine the effectiveness of an achievement goal intervention for improving student outcomes. Specifically, we explored whether manipulating feedback influenced cognition, motivation, academic achievement, and retention in the context of first-year undergraduate chemistry courses. Students' personal achievement goals, anxiety, self-efficacy, and metacognitive strategy use were measured at the beginning and end of the semester. After completing the first set of questionnaires, 217 students were randomly assigned to one of four conditions: a control condition, a mastery condition, a performance-approach condition, and a combined mastery/performance-approach condition. In each condition, students received a raw performance score for each weekly quiz they completed in an online learning environment and, for the treatment conditions, additional feedback reflective of that specific goal condition. Results revealed that all treatment groups had higher levels of self-efficacy at posttest, and the mastery goal and performance goal conditions had lower levels of anxiety at posttest compared to the control group. Finally, the control group had a higher percentage of students on probationary status at the end of the semester compared to the other groups. Receiving feedback beyond a performance grade was more beneficial in terms of learning outcomes compared to grades alone.

Increasing Academic Performance and Retention in Undergraduate Science Students: An Achievement Motivation Intervention

Over the past two decades, a majority of the theoretical and empirical work conducted in the achievement motivation literature has concentrated on achievement goal theory (Elliot & McGregor, 2001). Goal theory has developed within a social-cognitive approach to motivation that emphasizes cognitive factors, such as how individuals interpret situations, the events of situations, and how they process information about these situations (Dweck, 1986; Dweck & Leggett, 1988). Goals are one of the major determinants of how people feel about, react to, and cognitively process success or failure (Ames & Archer, 1988; Dweck, 1986;). Midgley, Kaplan, and Middleton (2001) define achievement goals as "the purposes for behavior that are perceived or pursued in a competence-relevant setting" (p.77).

Current theorists conceptualize achievement goals within a trichotomous (e.g., Elliot & Church, 1997; Middleton & Midgley, 1997; Pintrich, 2000a) or 2x2 achievement goal framework (Elliot & McGregor, 2001) that distinguish goals from a mastery-performance dichotomy and an approach-avoidance dichotomy. Within the trichotomous framework, three distinct achievement goal orientations have been proposed: a mastery goal, performance-approach goal, and a performance-avoidance goal. A mastery goal orientation (or mastery-approach orientation, as it is labeled in the 2x2 framework) describes learners who strive to develop competence and task mastery. Learners with a mastery goal orientation are theorized to believe effort and outcome covary. In contrast, a performance-approach goal orientation characterizes learners who strive to demonstrate aptitude and seek favorable judgments; competence is self-evaluated in comparison to others. The third goal is a performance-avoidance orientation, whereby learners strive to avoid appearing incompetent and avoid negative judgments. Like the performance-approach orientation, comparisons of competence are made with other individuals. Finally, the 2x2 achievement goal framework adds a fourth goal orientation: a mastery-avoidance orientation, whereby a learner's goal is to avoid failure rooted in an intrapersonal perspective (relative to oneself, like the mastery-approach orientation) rather than in comparison to others. For the mastery-avoidance goal construct, incompetence is the focus (Elliot & McGregor, 2001).

Presently, in the achievement motivation literature there is a pressing debate regarding whether adopting a mastery goal (the mastery, or normative, goals perspective) or multiple goals of mastery and performance-approach (the multiple goals perspective) results in better learning outcomes (Pintrich, 2000a). Traditionally, mastery goals are associated with positive learning outcomes, while performance-approach goals have been theoretically associated with less adaptive patterns of learning and achievement (Ames, 1992). However, several studies have empirically demonstrated that performance-approach goals can be beneficial to learning (e.g., Meece et al., 1988) and achievement (e.g., Pintrich, 2000a). Central to the multiple goals perspective is the notion that endorsing performance-approach goals is beneficial, particularly when mastery goals are also endorsed (Harackiewicz, Barron, Pintrich, Elliot, & Thrash, 2002). Educational implications of this debate for classroom reform need to be considered, especially in terms of the type of classroom contexts that are created.

The purpose of this research was to respond to this pressing debate. Specifically, we examined whether manipulating classroom goal structures decreased students' anxiety for learning, and increased their personal mastery and performance-approach goals, academic self-efficacy, use of metacognitive self-regulatory strategies, academic achievement, and retention in the context of first-year undergraduate chemistry courses. Why is this research important? First, this study addresses the ongoing achievement goal theory debate by examining how three classroom goal structures (mastery, performance-approach, combined mastery/performance-approach) relate to students' motivation and affect, learning strategies, and achievement. Second, student retention at the undergraduate level continues to be a critical issue. School retention is defined as the length of time a student remains enrolled at an institution toward completion of a program of study. According to the American College Testing Program (ACT, 2006), 40% of all students enrolled in four-year degree programs drop out, and 78-80% of those who do drop out will do so in their first year. According to a report by the Ontario Ministry of Training, Colleges and Universities (2005), 30 to 40% of all students enrolled in four-year degree programs drop out, and 78-80% of those who do drop out will do so in their first year. Similar levels have been reported in other provinces, such as Québec (25-35%, Montmarquette, Mahseredjian, & Houle, 2001). In a paper for the Commission of Inquiry on Canadian University Education, Gilbert (1991) estimated that after five years the non-completion rate for university undergraduates is approximately 42% across Canada.

Of particular concern, research on student retention has demonstrated that some disciplines have higher drop-out rates than others; science, mathematics, and engineering students are more likely to drop out than students in other disciplines (e.g., Daempfle, 2004). Results from Daempfle's research suggest the interaction of instructional factors and differing student expectations result in higher drop-out rates for this group of students. Moreover, each year approximately 35% of undergraduates fail introductory mathematics and science classes (Useem, 1992). According to the National Science Board (NSB, 2006), North America now imports much of its scientific and mathematical talent from other countries. The NSB warns there is an urgent need for more students to enter and complete careers that require a strong mathematics and science background as a function of the changing demographics and expected increases in the demand for scientists, mathematicians, and engineers. In the New Economy that requires such expertise (Eccles, 1997), improving student retention and performance in the sciences is becoming a necessity. Because of these growing concerns, research is needed that focuses on increasing retention and achievement in undergraduate science. This research addresses these concerns by implementing an intervention designed to increase student achievement and retention. Prior to describing the intervention, we review relevant theoretical frameworks and empirical work, and present the research questions and hypotheses.

Student Retention and Motivation

Over the past four decades, two prominent theoretical models on college persistence have emerged (e.g., Bean, 1980; Tinto, 1993). Tinto’s (1993) theory of student integration proposes that particular background characteristics such as family, socio-economic status (SES), and high school performance (e.g., GPA) help determine a student’s integration into a university’s academic and social structures. This integration establishes a student’s commitment to the institution and goals for completion. Bean’s (1980) student drop-out model focuses on behavioural indicators, particularly contact with faculty and time spent away from campus. These indicators represent a proxy for student interaction and lack of involvement, respectively. A considerable amount of research has been conducted to scrutinize these models and has found support for the “traditional” factors as good predictors of student retention (e.g., Beil, Reisen, Zea, & Caplan, 1999; Berger & Milem, 1999). Moreover, research has found a consistent relationship between college academic achievement and retention; students who perform higher persist in their studies to a greater degree than lower-achieving students (Kirby & Sharpe, 2001; McGrath & Braunstein, 1997).

Recently, researchers have begun to focus their attention on psychosocial and study skills factors as predictors of retention (e.g., DeBerard, Spielmans, & Julka, 2004; Harackiewicz et al., 2002). Typically, studies that focus on psychosocial and study skills factors examine to what extent these types of variables, such as achievement goals, academic self-efficacy, and study strategies, predict academic performance and retention above and beyond traditional predictors. In a meta-analysis of 109 studies that focused on traditional, psychosocial, and study skills factors to predict college outcomes, Robbins, Lauver, Le, Davis, Langley, and Carlstrom (2004) found the best predictors of retention were academic goals, academic self-efficacy, and study skills Moreover, the best predictors of academic achievement (GPA) were academic self-efficacy and achievement goals. Accordingly, motivation variables play an important role in college success.

Research that Muis and colleagues have conducted supports this notion (e.g., Biesinger, Crippen, Muis, & Orgill, in 2009; Muis, Winne, & Edwards, 2009; Winne, Muis, & Jamieson-Noel, 2005). For example, Winne et al. (2005) examined relations among students' achievement goals, self-reported metacognitive self-regulation (e.g., planning, monitoring, and control strategies), self-efficacy, and achievement across various academic tasks in an undergraduate course. They found positive relations between a mastery goal orientation and metacognitive self-regulation, self-efficacy, and achievement. The more individuals espoused a mastery goal orientation, the higher their self-efficacy for learning, the more they reported using metacognitive self-regulation strategies and the higher they performed on academic tasks. Similarly, positive relations were found between a performance-approach goal orientation, metacognitive self-regulation, and achievement.

Generally, mastery goals are positively related to various learning variables including cognitive engagement and self-reported self-regulatory strategies (e.g., Pintrich, 2000b), self-efficacy, interest, and value (e.g., Harackiewicz et al., 2000; Wolters et al., 1996), higher positive affect and lower negative affect (e.g., Kaplan & Maehr, 1999; Middleton & Midgley, 1997), and help seeking (e.g., Ryan & Pintrich, 1998). Moreover, researchers have found that a mastery orientation is positively related to achievement outcomes (e.g., Church, Elliot, & Gable, 2001; Kaplan & Maehr, 1999).

In contrast, reported relations between various learning and achievement variables and a performance-approach goal orientation differ across studies. While some studies showed that performance-approach orientation correlates positively with effective cognitive engagement (e.g., Meece et al., 1988; Wolters et al., 1996) and achievement (Bouffard et al., 1998; Harackiewicz et al., 2000; Pintrich, 2000a), some have demonstrated negative relations between performance-approach goals and self-efficacy (e.g., Skaalvik, 1997), as well as positive relations with negative affect and test anxiety (e.g., Kaplan & Maehr, 1999; Middleton & Midgley, 1997) and with avoidant help seeking (Ryan & Pintrich, 1998). However, when performance-approach goals are coupled with mastery goals, the combination has resulted in positive learning and achievement outcomes (e.g., Pintrich, 2000a).

Goal theorists are not solely interested in predicting relations at the group level; they are also interested in changing achievement goal orientations and examining those changes within individuals as a function of features of classroom or school goal structures. Classroom goal structures are similar to personal achievement goals wherein a mastery goal structure is an environment, created by the teacher, that focuses on student mastery and self-improvement. In contrast, a performance-approach classroom goal structure is an environment that a teacher creates that focuses on student competition and high achievement.

Of particular interest, several studies have examined how students' personal achievement goals change as a function of modifications in the classroom goal structure, and how this influences self-efficacy, self-regulatory skills, and achievement. Researchers have typically found that a combined mastery and performance-approach classroom goal orientation is related to students' adoption of mastery and performance-approach goals (e.g., Linnenbrink, 2005; Roeser, Midgley, & Urdan, 1996; Urdan, 2004; Urdan & Midgley, 2003) as well as increases in students' motivation (e.g., self-efficacy), emotional well-being, cognitive engagement, help seeking, and achievement (e.g., Ames & Archer, 1988; Kaplan & Midgley, 1999; Roeser et al., 1996).

For example, Linnenbrink (2005) examined the effects of classroom goal condition (mastery, performance-approach, and a combined mastery/performance approach) and entering personal goal orientations on motivation, help-seeking, emotional well being, cognitive engagement, and achievement with a sample of upper-year elementary students. At the end of the study, Linnenbrink found that students in the mastery condition reported higher personal mastery goals than students in the performance-approach condition. Similarly, students in the performance-approach condition reported higher personal performance-approach goals than students in the mastery goal condition. Moreover, the combined mastery/performance approach classroom goal condition had the greatest positive effect on achievement and help seeking.

In summary, research has consistently demonstrated that changes in classroom goal structures influence individuals' personal achievement goals. Why is this important for improving college success? Studies have found that increasing students' achievement goals increases motivation, cognitive engagement, and achievement. Given that previous research on student retention has demonstrated these factors to be positive predictors, if treatments can be implemented into classrooms that increase motivation, cognitive engagement, and achievement, then retention may also increase.

Furthermore, increasing students' mastery goal orientation may have other beneficial factors on retention. For example, Harackiewicz et al. (2002) examined the role of achievement goals, ability, and high school performance in predicting academic success over students' college careers. They assessed which variables predicted students' interest and performance in their first semester at university. Students were followed until they graduated to examine continued interest and performance in subsequent courses. Results revealed that achievement goals, ability measures, and prior high school performance predicted initial and long-term outcomes. Mastery goals predicted continued interest, whereas performance-approach goals predicted performance. Ability measures and prior high school performance predicted academic performance but did not predict interest. As Harackiewicz et al. argued, to improve student performance and increase retention, university professors should develop classroom environments that focus on performance as well as mastery of the content. This study responds to that call.

We examined two research questions. The first question addresses the debate regarding the mastery goals versus multiple goals perspective: What is the most adaptive classroom goal context (mastery, performance-approach, or combined mastery/performance-approach) for reducing anxiety and for promoting self-efficacy, cognitive engagement (e.g., metacognitive self-regulation), and achievement? We predict that if the multiple goals perspective is supported, the combined mastery/performance approach condition will be most adaptive across outcomes, with the mastery condition having some benefits in terms of self-efficacy, anxiety, and metacognitive self-regulation, and the performance-approach condition having some benefits for metacognitive self-regulation and achievement. For the control group, we expected no benefit for any of the outcomes. The second question addresses retention: What influence does manipulating classroom goal structures have on student retention? We predicted that the control group will have the lowest level of student retention. We further predicted that students in the combined condition will benefit greatest in terms of student retention, with the other two goal conditions benefiting but not to the same extent as the combined condition. To explore these two research questions, we conducted two studies, one in each of two required first-year undergraduate chemistry courses.

Study 1 - Methodology

Participants

Two hundred seventeen undergraduate university students consented to participate in the study ($N = 120$ females). Students were enrolled in a prerequisite qualifying first-year inorganic chemistry course for science majors. The mean age was 20.30 ($SD = 5.39$) and the mean self-reported high school GPA was 3.65 (out of a 4.50, $SD = .49$). Because of the repeated nature of the study, a number of students' data was not usable due to attrition. To ensure there were no differences between the two groups (i.e., those who dropped from the study versus those who completed the study), we conducted a multivariate analyses of variance on all variables. Results revealed no differences between groups ($p > .10$), with the exception of students' final grade, $F (3, 214) = 24.02$ (students who dropped from the study had a final grade that was 12 points less than students who completed the study). We then compared final grade as a function of experimental condition for the dropout group. No differences were found. Accordingly, the final sample size was 125 ($N = 76$ females), with a mean age of 20.10 ($SD = 5.32$) and mean self-reported high school GPA of 3.71 (SD = .48). Moreover, 73% of the final sample was majoring in biology, biochemistry, or chemistry.

Materials

Prior Knowledge. To measure prior knowledge of course content, participants completed a prior knowledge test. This ten-item multiple-choice test measured students' knowledge of various chemistry concepts including properties of matter, electronic configurations, chemical reactions, and stoichiometry (see Appendix A).

Achievement Goals. To assess students' mastery, performance-approach, and performance-avoidance goal orientations, the student version of the Patterns of Adaptive Learning Scales (PALS; Midgley et al., 2000) was used. The PALS is a well validated and reliable 14-item Likert-scale instrument designed to measure personal achievement goals within a trichotomous framework (i.e., mastery-avoidance goals are not measured). Mastery goals were assessed with items like, "My goal was to make sure that I learned how to read and interpret graphs" (reliability, Cronbach's alpha, was .84). Performance-approach goals were assessed with items such as, "I wanted to be better at reading and interpreting graphs than the students in the other groups" (reliability, Cronbach's alpha, was .86). Finally, performance-avoidance goals were assessed with items like, "It's important that I don't look stupid in class" (reliability, Cronbach's alpha, was .77) Items on the PALS are anchored along a 5-point scale ranging from 1 (not at all true) to 5 (very true). Responses to the items within each subscale are summed and then averaged to obtain a subscale score for each participant. (see Appendix B).

Self-Efficacy, Anxiety, and Metacognitive Self-Regulation. Items from the self-efficacy, anxiety, and metacognitive self-regulation subscales of the Motivated Strategies for Learning Questionnaire (MSLQ; Pintrich et al., 1991) were used. The MSLQ is a widely used and well validated 81-item self-report measure designed to assess undergraduate students' use of varying learning strategies and motivational orientations for an undergraduate course. The self-efficacy for learning and performance subscale of the MSLQ is comprised of 8 items, and assesses expectancy for success and self-efficacy. Expectancy for success refers specifically to task performance, and self-efficacy includes judgments of one's ability to successfully complete a task as well as one's confidence in one's skills to perform that task. Example items include, "I believe I will receive an excellent grade in this class" (expectancy for success), and "I'm confident I can learn the basic concepts taught in this course" (self-efficacy) (reliability, Cronbach's alpha, was .91). The anxiety subscale of the MSLQ includes five items that measure a student's level of anxiety for learning course content and taking course exams. An example item includes, "I have an uneasy, upset feeling when I take an exam" (reliability, Cronbach's alpha, was .78). Finally, the metacognitive self-regulation subscale includes twelve items that measure processes of planning, monitoring and regulating cognitive activities. An example item is "When studying for this course I try to determine which concepts I don't understand well" (reliability, Cronbach's alpha, was .80). Students rate each statement on a 7-point Likert scale ranging from "not at all true of me" (a rating of 1) to "very true of me" (a rating of 7). For all of these subscales, higher scores indicate greater agreement and thus greater strategy use (see Appendix C.)

Achievement. Achievement was measured using the overall course raw score, which was then converted into a percent (out of 100). This measure was computed as a non-weighted compilation of grades from three exams, a final exam, a cumulative online quiz score, laboratory work, and a cumulative in-class quiz score.

Retention. Unfortunately, at the time of the completion of the study, student withdrawal information was not released from the registrars' office. To address this issue, we focused on one measure that could serve as a proxy–student probationary status. In the science departments at the university wherein this study was conducted, students must obtain grades of C- or higher in required courses in order to qualify for more advanced courses. If a student receives a grade below C- (e.g., a D or F), he or she is placed on probationary status and is given one year within which to complete the course with a grade of C- or higher. If the course is not satisfactorily completed within that timeframe, the student must withdraw from the program. Accordingly, to measure student retention, we used probationary status as a proxy to measure student retention. Students who received grades below C- were coded as probationary, whereas students receiving a grade of C- or above were coded as non-probationary.

The Online Learning Environment and Achievement Goal Conditions

Each achievement goal condition (mastery, performance-approach, combined mastery/performance-approach, control condition) was established in the online learning environment that all students were required to use for this course. The online assessment environment, developed by Crippen (see Crippen & Earl, 2004), was used to track students' progress and to provide feedback on course assessments. Each week, students were required to complete a content quiz (online only). At any point during the week, students had access to their quiz answers and could modify their responses at any time. At the end of each week, quizzes were graded and students were given performance feedback (a raw score out of 10, one point for each correct answer). If a score of at least 8 points out of 10 was not achieved, students were given the opportunity to complete a make-up quiz, which was available for four days following the original quiz. Moreover, based on the condition under which students were randomly assigned, each goal condition received additional feedback about their quiz performance (with the exception of the control condition). With the exception of variations in types of feedback, the four online learning environments were otherwise identical in content, layout, etcetera.

Goal conditions were created via the type of feedback that students received on each weekly quiz. Following Linnenbrink's (2005) protocol, feedback in the mastery goal condition (n = 35) emphasized the importance of learning, understanding, and improvement. For example, each week, students in the mastery condition were provided information in graphical form that indicated how much they improved (or did not improve) on that week's assessment compared to previous weeks. Messages that improvement, progress, and understanding of content are important were also made salient. In contrast, feedback in the performance-approach condition (n = 39) emphasized the importance of demonstrating individual competence, with a particular emphasis on competition for high scores. For this condition, each week, students were provided performance feedback in graphical form that indicated how well they performed compared to other students. Moreover, their percentile rank was provided and messages were made salient regarding the importance of high grades compared to others. Feedback in the combined mastery/performance-approach condition (n = 27) included elements of both the mastery and performance-approach conditions, with an emphasis on doing better than others *and* trying to learn and understand. For this condition, students were provided information on their improvement from week to week as well as how well they performed compared to others. Like the other two conditions, this information was displayed in graphical form. Percentile rank was also provided along with messages that improvement, progress, understanding, and high performance compared to others are important. Finally, with the exception of a single performance score for each quiz, the control condition received no additional feedback (n = 24).

Scores were not compared to previous weeks' scores or to other students' scores. (See Appendix D for web links to each condition.)

Procedure

Students were randomly assigned to one of the four conditions: mastery feedback, performance-approach feedback, combined mastery/performance-approach feedback, and a control group. Within the first week of the course, and prior to any assessments, students completed a demographics questionnaire, a prior knowledge test, and items from the PALS and MSLQ using the online learning system designed for the course. Over the course of the semester, students received weekly feedback about their performance in the course. After quizzes were graded, feedback was automatically displayed upon login to ensure students received their performance evaluation. At the end of the semester, prior to students completing the final exam, students were asked to complete the PALS and MSLQ items again.

Results

Preliminary Analyses

Using a MANOVA, we first explored whether there were any treatment group differences at pretest on prior knowledge, high school GPA, self-efficacy, anxiety, metacognitive self-regulation, mastery goals, performance-approach goals, and performance-avoidance goals. Results revealed no differences between groups on any of these variables (Pillai's trace $F(24, 492) = .94$, $p = .54$). We then assessed for differences on these variables as a function of gender. Independent samples t-test results revealed gender differences on self-efficacy, anxiety, metacognitive self-regulation, and mastery orientation (all $p < .05$). Accordingly, gender was used as a covariate for subsequent analyses. All means, standard deviations, and reliability coefficients are presented in Tables 1 through 4 for all variables at pretest and posttest. Figures 1 through 6 present means for each of the variables from pretest to posttest for ease of comparison.

Table 1. *Descriptive Statistics and Reliability Coefficients for All Variables*

	Pretest			Posttest		
	Mean	SD	α	Mean	SD	α
Prior Knowledge Score	3.33	1.89	-	-	-	-
High School GPA	3.71	.48	-	-	-	-
Final Grade (%)	-	-	-	77.90	13.09	-
Self-Regulation Variables[b]						
Self-Efficacy	5.64	1.00	.91	5.47	1.15	.94
MSR	5.03	.83	.80	4.91	.98	.86
Anxiety	3.96	1.35	.78	4.02	1.31	.79
Personal Goal Orientations[c]						
Mastery Goal	4.70	.53	.84	4.61	.59	.88
Performance-Approach Goal	2.41	1.02	.86	2.29	1.04	.90
Performance-Avoid Goal	2.34	.99	.77	2.30	.96	.79

Note: SD = standard deviation, MSR = metacognitive self-regulation, [a] N = 125, [b]1-7 point scale, [c]1-5 point scale

Table 2. *Descriptive Statistics for Prior Knowledge, GPA, and Final Grade by Condition*

	N	Mean	SD
Prior Knowledge			
Control	24	3.54	2.21
Mastery	35	3.14	1.67
Performance	39	3.38	1.65
Combined	27	3.30	2.25
High School GPA			
Control	24	3.75	.44
Mastery	35	3.40	.50
Performance	39	3.88	.41
Combined	27	3.81	.45
Final Grade			
Control	24	74.08	15.69
Mastery	35	77.76	11.17
Performance	38	79.59	12.24
Combined	27	78.58	14.06

Note: SD = standard deviation

Table 3. *Descriptive Statistics for SRL[a] Variables by Condition*

		Pretest		Posttest	
	N	Mean	SD	Mean	SD
Self-Efficacy[b]					
Control	24	5.61	.91	4.96	1.21
Mastery	35	5.73	.88	5.64	1.07
Performance	39	5.74	.90	5.63	.98
Combined	27	5.41	1.32	5.47	1.33
Metacognitive Self-Regulation[b]					
Control	24	4.78	.79	4.66	.81
Mastery	35	4.98	.78	4.95	.96
Performance	39	5.20	.85	4.90	1.05
Combined	27	5.10	.88	5.08	1.07
Anxiety[b]					
Control	24	4.09	1.16	4.52	1.16
Mastery	35	3.67	1.46	3.66	1.40
Performance	39	3.98	1.27	3.87	1.27
Combined	27	4.21	1.48	4.20	1.21

Note: SD = standard deviation, [a] SRL = self-regulated learning, [b]1-7 point scale

Table 4. *Descriptive Statistics for Goal Orientations by Condition*

		Pretest		Posttest	
Variables	N	Mean	SD	Mean	SD
Mastery Goal[a]					
Control	24	4.73	.52	4.57	.56
Mastery	35	4.78	.39	4.66	.59
Performance	39	4.68	.55	4.65	.64
Combined	27	4.59	.66	4.53	.57
Performance-Approach Goal[a]					
Control	24	2.67	1.14	2.41	1.14
Mastery	35	2.13	.95	1.82	.89
Performance	39	2.47	.99	2.51	1.09
Combined	27	2.47	.99	2.52	.93
Performance-Avoid Goal[a]					
Control	24	2.59	1.12	2.30	1.09
Mastery	35	2.07	.94	1.91	.77
Performance	39	2.39	.93	2.45	1.01
Combined	27	2.38	.99	2.56	.89

Note: SD = standard deviation, [a] 1-5 point scale

Figure 1

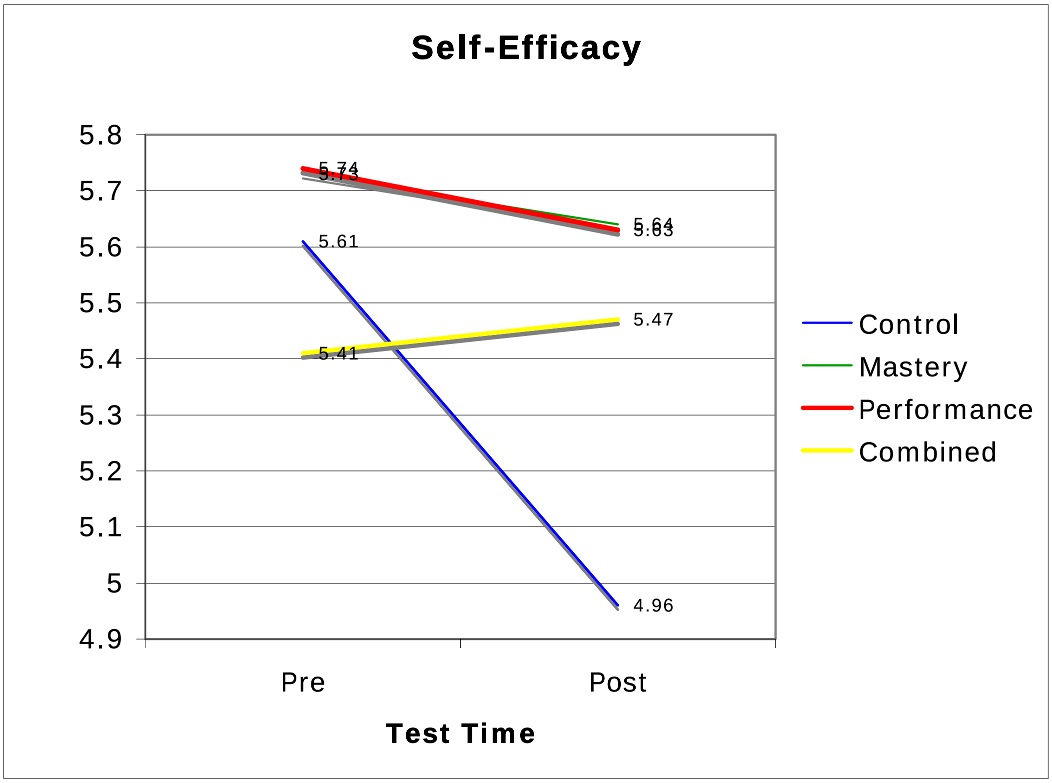


Figure 2

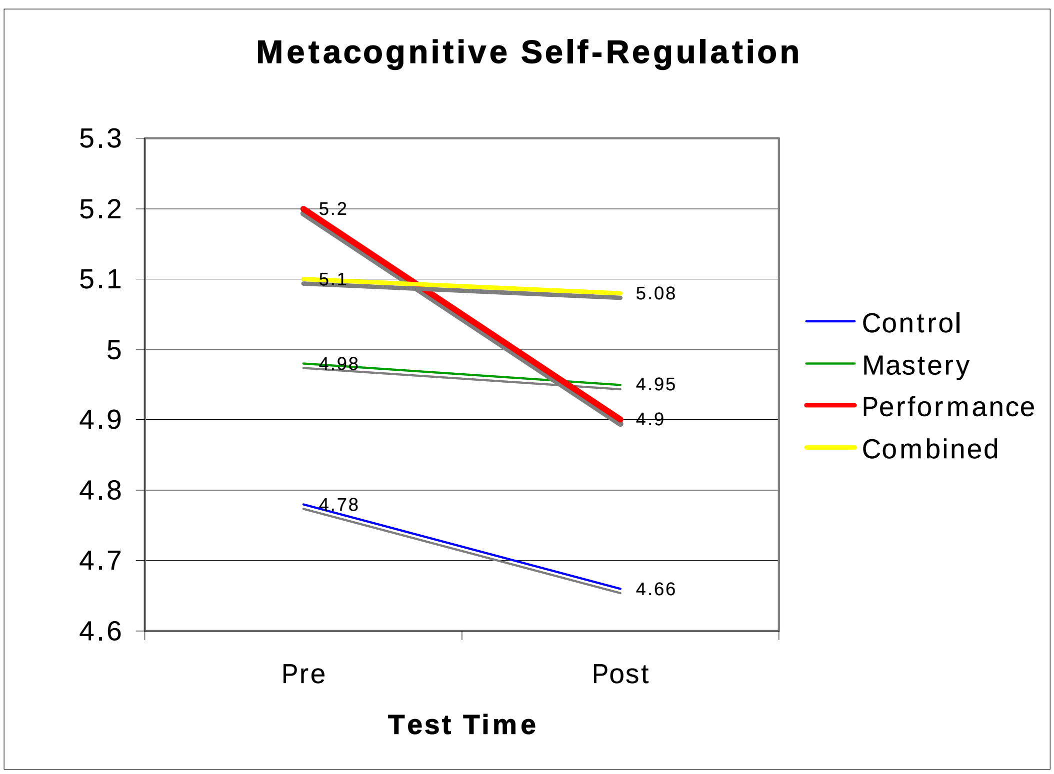


Figure 3

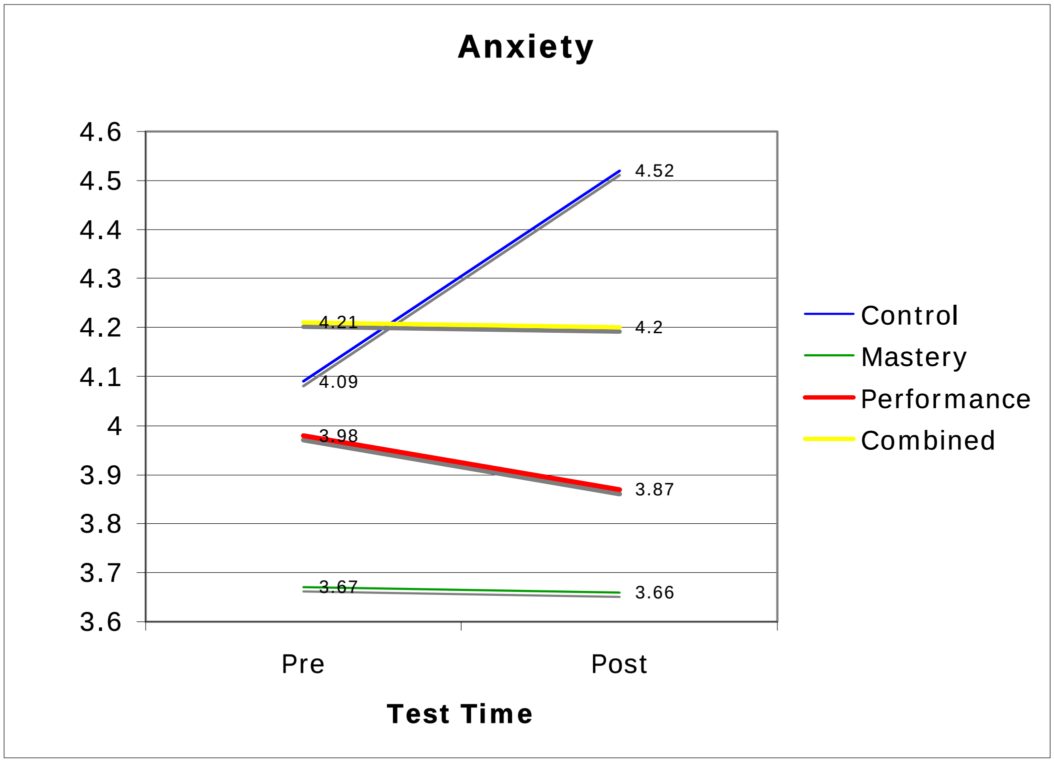


Figure 4

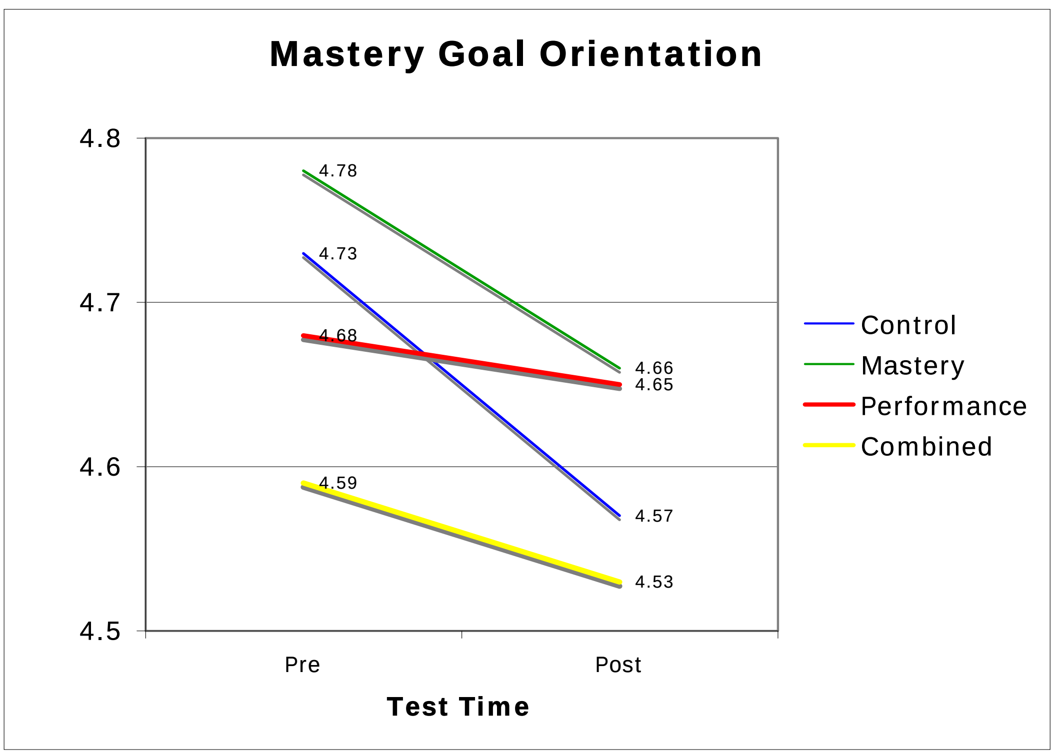


Figure 5

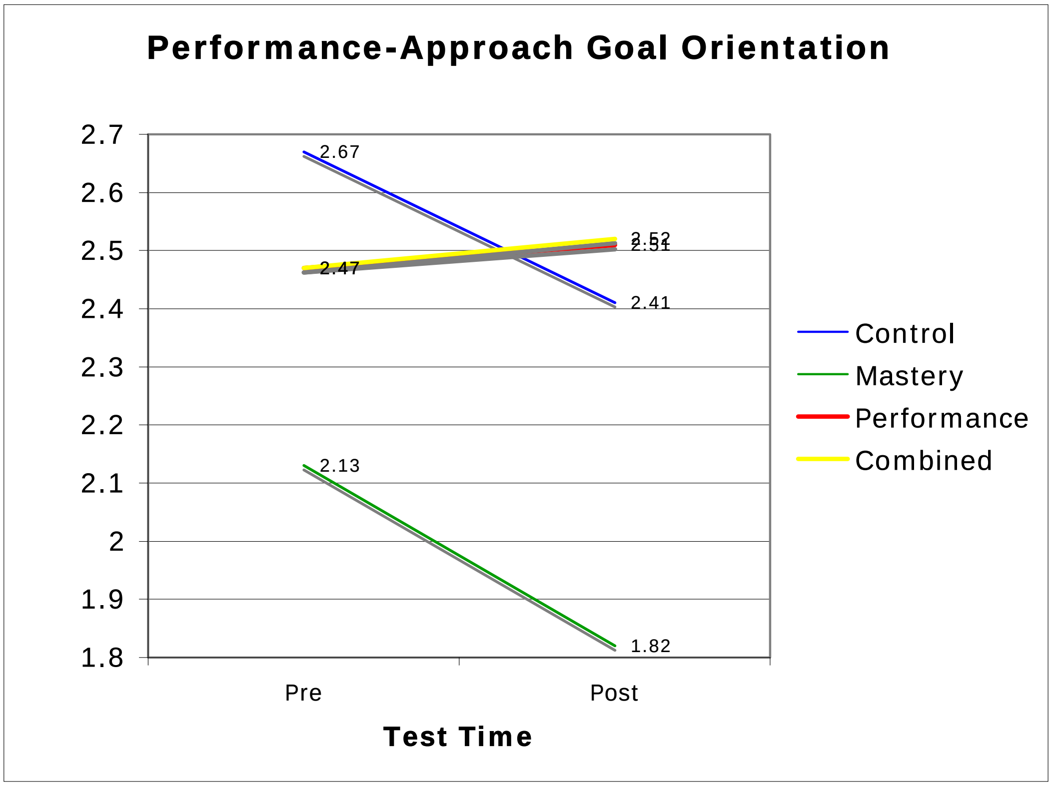
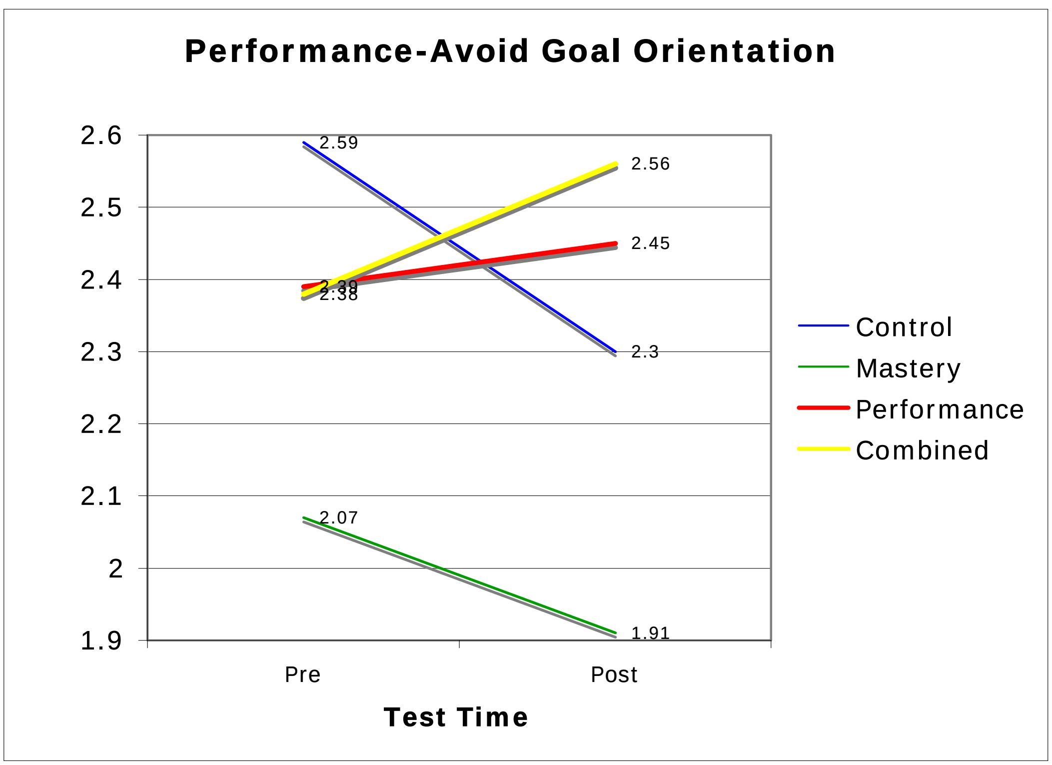


Figure 6



Effects of Goal Condition on Posttest Outcomes Across Groups

To examine the effects of goal condition on students' academic performance (final grade), self-efficacy, anxiety, metacognitive self-regulation, and mastery goal, performance-approach goal, and performance-avoidance goal orientations, a multivariate analysis of covariance (MANCOVA) was conducted, with gender as the covariate and goal condition (control, mastery, performance-approach, and mastery/performance-approach) as the independent variable. A significant omnibus F was obtained, $F(21, 345) = 4.21$, $p < .05$, $\eta^2 = .12$, Pillai's Trace = .03. These results suggest that goal condition had a significant effect on student outcomes. Accordingly, univariate results were examined.

Results from the univariate tests showed significant differences between groups on end-of-semester self-efficacy, $F(3, 119) = 2.09$, $p < .05$, $\eta^2 = .05$, anxiety, $F(3, 119)$ 2.39, $p < .05$, $\eta^2 =.06$, performance-approach goal orientation, $F(4, 119) = 3.58$, $p < .05$, $\eta^2 = .08$, and performance-avoidance goal orientation, $F(3, 119) = 2.96$, $p < .05$, $\eta^2 = .07$. Post hoc follow-up analyses using the LSD procedure revealed that all three experimental groups had a higher self-efficacy than the control group (effect sizes were d = .59 for mastery compared to the control group, .61 for performance approach, .and .41 for the combined group), and that the mastery only (d = -.67) and performance-approach only (d = -.54) goal conditions had significantly lower levels of anxiety than the control group (all ps < .05). Moreover, for personal goal orientations, the mastery goal group had a significantly lower level of personal performance-approach goals compared to all three other groups (d = -.69, -.77, and -.57 for mastery compared to performance-approach group, combined group, and control group, respectively) and significantly lower personal performance-avoidance goals compared to the performance-approach (d = -.81) and combined groups (d = -.77) (all ps < .05).

Effects of Goal Condition Within Groups

To examine the effects that the feedback conditions had on students' personal goal orientations at posttest, we conducted a repeated measures analysis of covariance, with gender as the covariate. We predicted that students in the control group should show no change in personal achievement goal orientations from pretest to posttest, that students in the mastery group should increase in personal mastery goal orientation, that students in the performance-approach group should increase in performance-approach goals, and that students in the combined condition should increase in both mastery and performance-approach goals. Results revealed a significant main effect of goal, F (2, 238) = 329.46, $p < .001$, $\eta^2 = .74$, a main effect of feedback, F = 3, 119) = 2.34, $p < .05$, $\eta^2 = .08$, and significant goal x feedback, F (6, 238) = 3.50, $p < .05$, $\eta^2 = .06$, time x gender, F (1, 119) = 2.62, $p < .05$, $\eta^2 = .02$, time x feedback, F (3, 119) = 2.10, $p < .05$, $\eta^2 = .05$, and goal x time x gender, F (2, 238) = 2.71, $p < .05$, $\eta^2 = .02$, interactions.

Based on these results, we conducted paired samples t-tests as a function of goal condition and gender to explore which groups differed from pretest to posttest on each of the achievement goal orientations. Means and standard deviations for all variables as a function of condition and gender are presented in Tables 5 and 6. Figures 7 through 12 are also displayed for ease of comparison. Of particular interest, for the mastery goal condition, males' level of performance-approach orientation significantly decreased from pretest to posttest, t(14) = 2.41, $p < .05$. For the combined group, females' level of performance-avoidance orientation significantly increased from pretest to posttest, t(15) = -2.89, $p < .01$. No other differences were found.

Table 5. *Descriptive Statistics for SRL Variables by Condition x Gender*

	N		Pretest Mean (SD)		Posttest Mean (SD)	
	F	M	F	M	F	M
Self-Efficacy[b]						
Control	16	8	5.41 (.96)	6.02 (.69)	5.05 (1.09)	4.78 (1.50)
Mastery	20	15	5.59 (1.00)	5.90 (.69)	5.61 (1.11)	5.68 (1.03)
Performance	24	14	5.68 (.87)	5.96 (.88)	5.63 (.99)	5.63 (1.01)
Combined	16	11	5.27 (1.43)	5.60 (1.18)	5.32 (1.54)	5.68 (.98)
Metacognitive Self-Regulation[b]						
Control	16	8	4.80 (.75)	4.75 (.93)	4.85 (.80)	4.29 (.76)
Mastery	20	15	5.18 (.91)	4.72 (.47)	5.11 (1.02)	4.73 (.85)
Performance	24	14	5.41 (.75)	4.89 (.95)	5.10 (1.02)	4.57 (1.05)
Combined	16	11	5.10 (.83)	5.08 (.99)	5.02 (1.21)	5.16 (.88)
Anxiety[b]						
Control	16	8	4.15 (1.28)	3.98 (.96)	4.34 (1.30)	4.88 (.78)
Mastery	20	15	4.14 (1.38)	3.05 (1.36)	4.08 (1.22)	3.09 (1.46)
Performance	24	14	4.45 (1.11)	3.19 (1.19)	4.03 (1.45)	3.61 (.90)
Combined	16	11	3.81 (1.39)	4.78 (1.47)	4.06 (1.07)	4.40 (1.43)

Note: SD = standard deviation, F = female, M = male, [b]1-7 point scale.

Table 6. Descriptive Statistics for Goal Orientations by Condition x Gender

	N		Pretest Mean (SD)		Posttest Mean (SD)	
	F	M	F	M	F	M
Mastery Goal[a]						
Control	16	8	4.76 (.54)	4.65 (.50)	4.63 (.59)	4.45 (.52)
Mastery	20	15	4.87 (.34)	4.67 (.43)	4.67 (.67)	4.65 (.48)
Performance	24	14	4.83 (.46)	4.50 (.62)	4.78 (.55)	4.41 (.73)
Combined	16	11	4.74 (.39)	4.36 (.90)	4.63 (.44)	4.40 (.72)
Performance-Approach Goal[a]						
Control	16	8	2.71 (1.17)	2.58 (1.16)	2.64 (1.20)	1.95 (.94)
Mastery	20	15	2.03 (.87)	2.25 (1.07)	1.90 (.99)	1.71 (.77)
Performance	24	14	2.39 (.94)	2.67 (1.09)	2.45 (1.13)	2.60 (1.04)
Combined	16	11	2.26 (.79)	2.78 (1.19)	2.49 (1.00)	2.56 (.87)
Performance-Avoid Goal[a]						
Control	16	8	2.66 (1.08)	2.47 (1.28)	2.53 (1.19)	1.84 (.74)
Mastery	20	15	2.06 (.79)	2.08 (1.14)	1.96 (.79)	1.85 (.77)
Performance	24	14	2.38 (.94)	2.48 (.95)	2.41 (1.04)	2.54 (.97)
Combined	16	11	2.33 (.76)	2.45 (1.30)	2.63 (.96)	2.48 (.80)

Note: SD = standard deviation, F = female, M = male, [a] 1-5 point scale

Figure 7

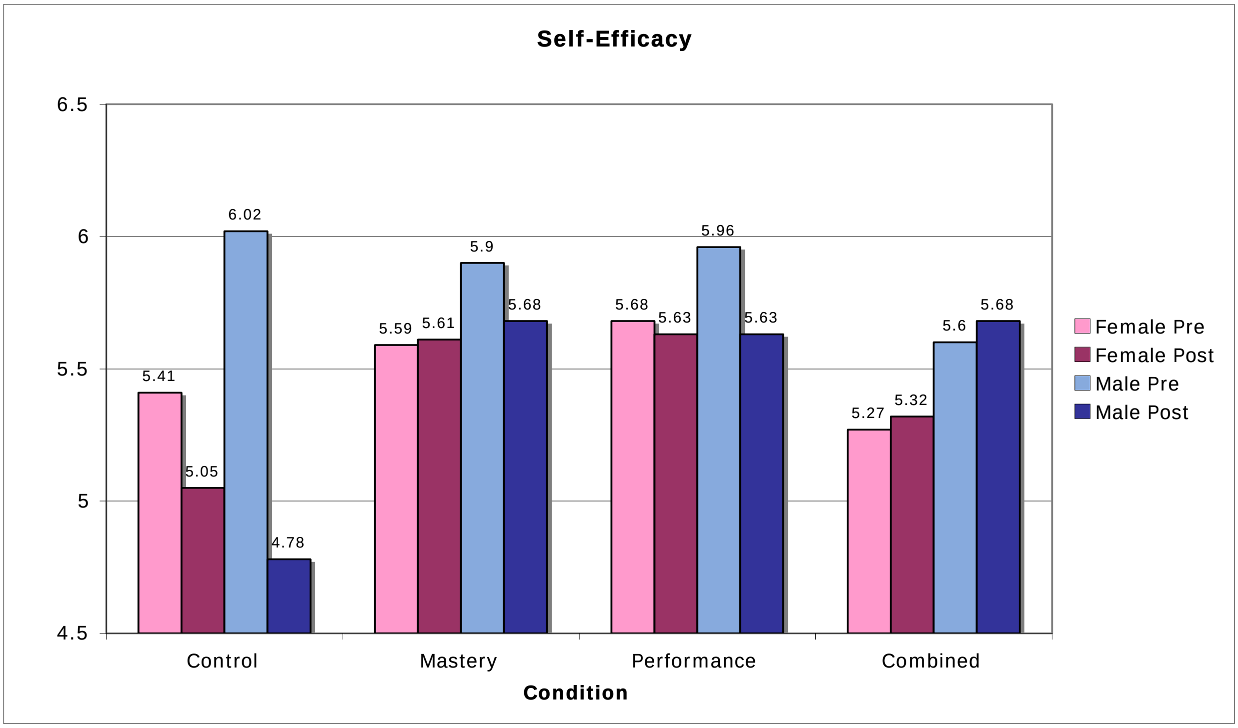


Figure 8

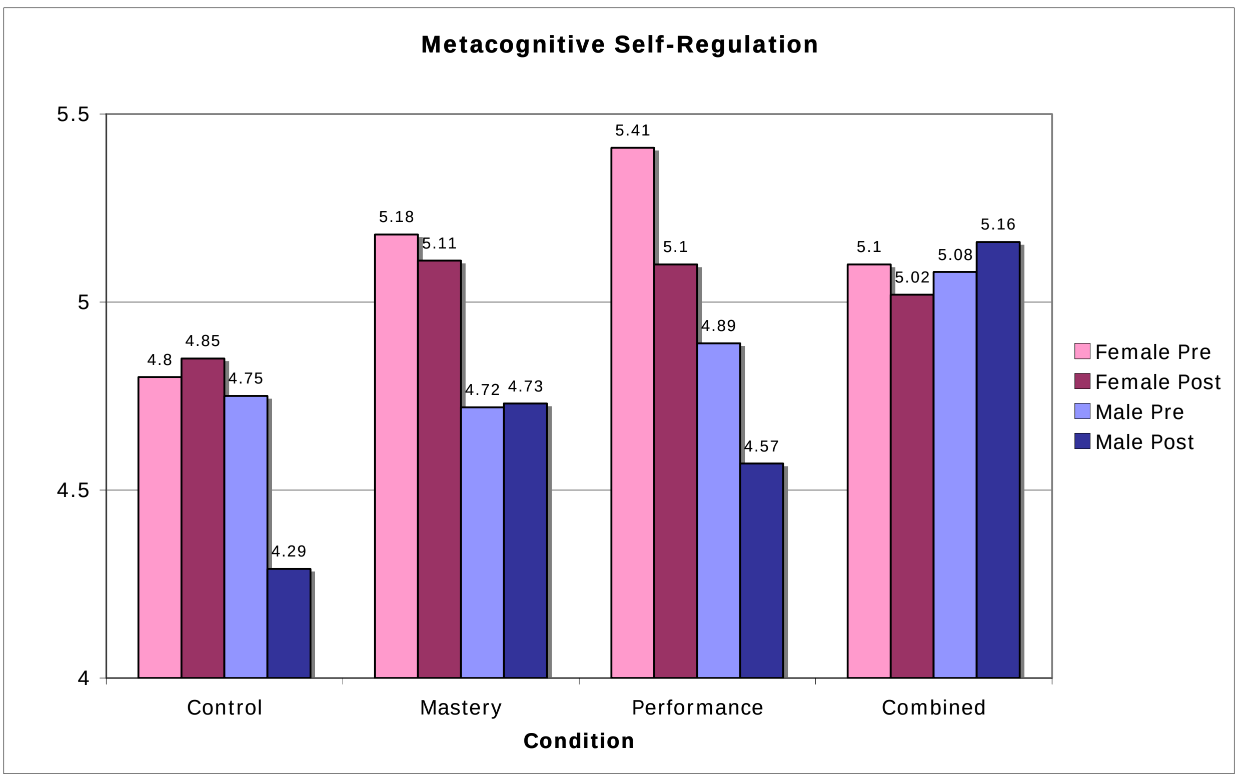


Figure 9

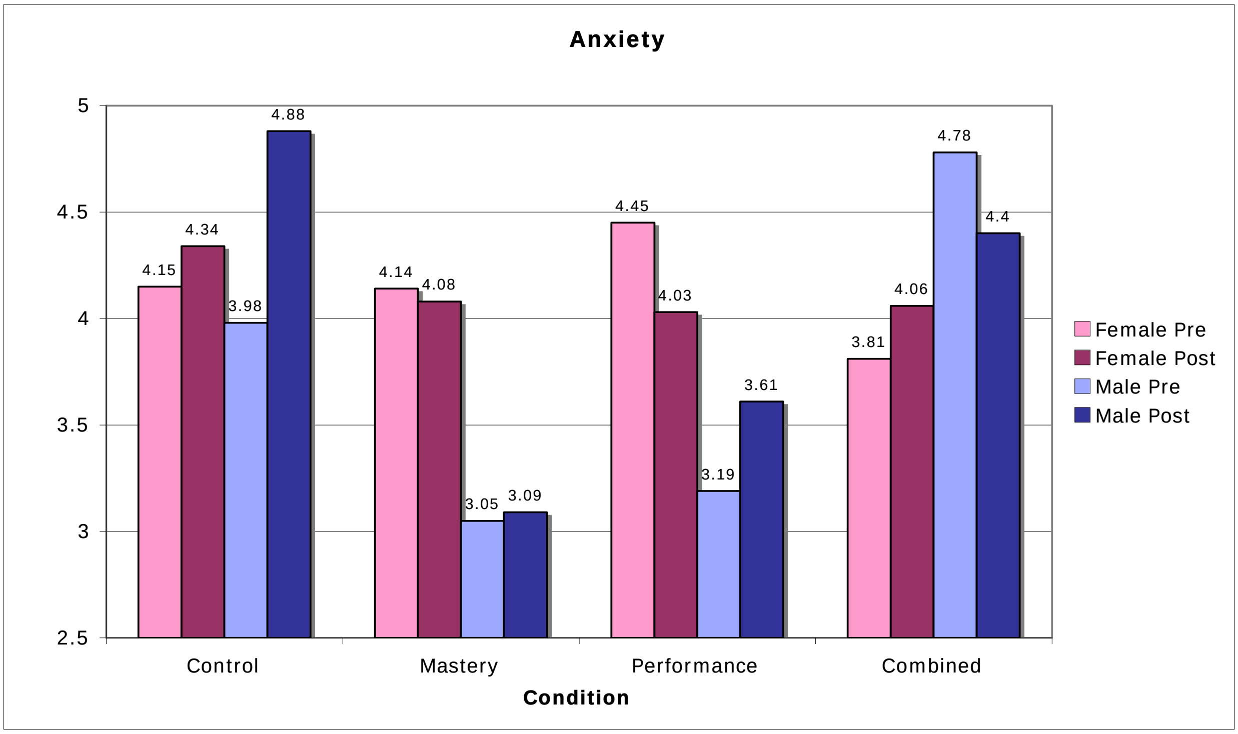


Figure 10

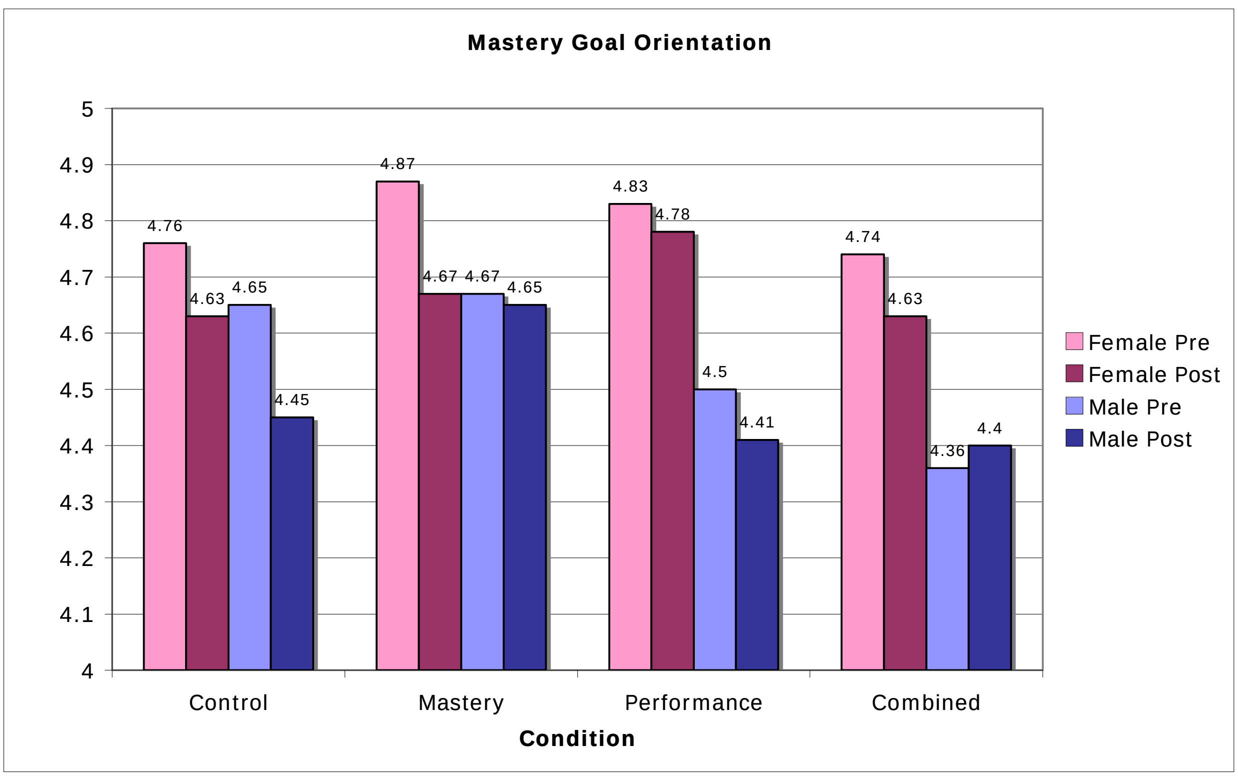


Figure 11

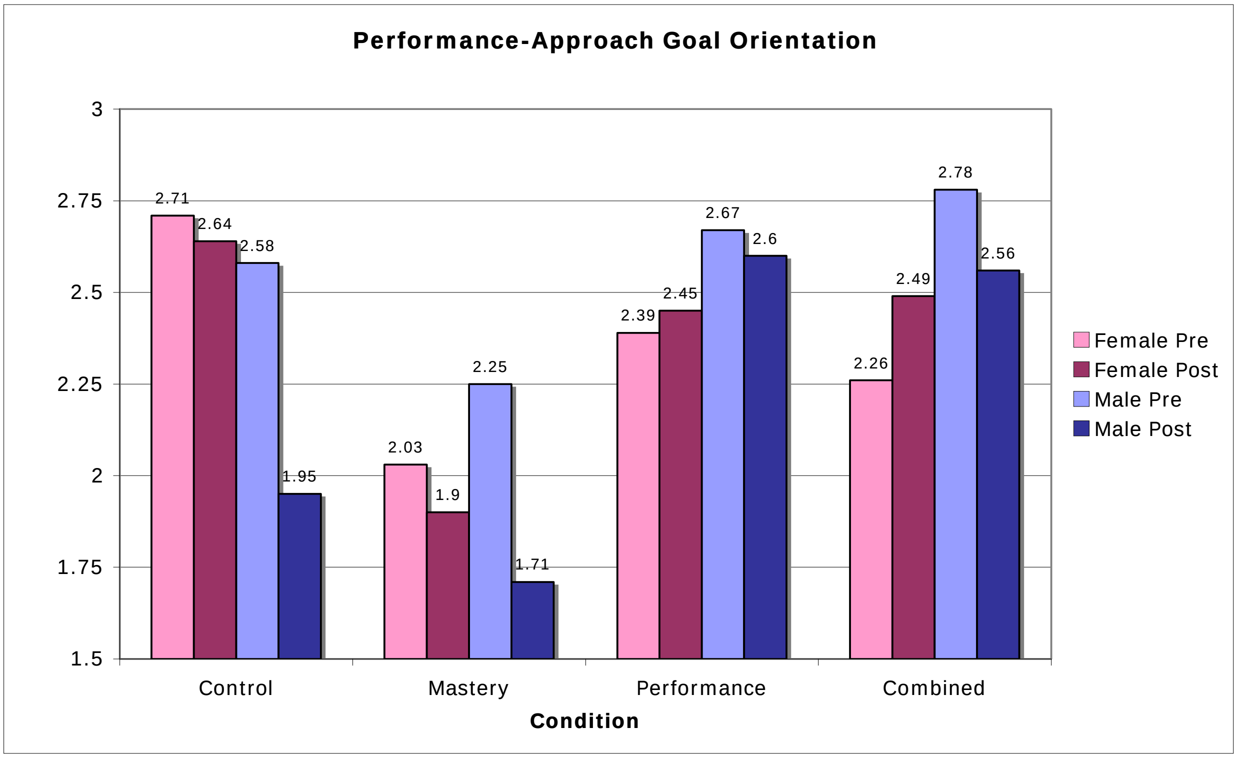
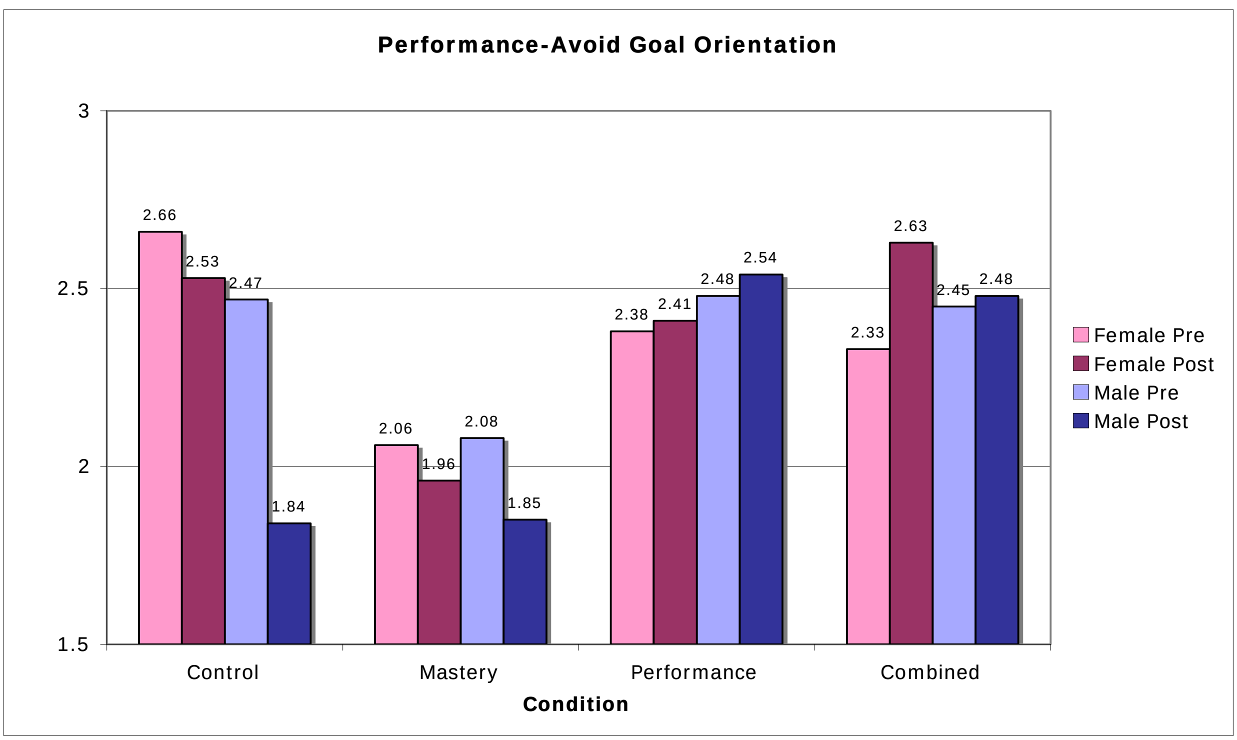


Figure 12



Similar analyses were carried out for self-efficacy, anxiety, and metacognitive self-regulation (which we labeled as "cognition/affect") to explore pretest/posttest differences as a function of group. We predicted that students in the control group should experience no changes in these variables, whereas students in the other three groups should experience increases in self-efficacy and metacognitive self-regulation, and a decrease in anxiety. Accordingly, a repeated measures analysis of variance was conducted to assess whether students' self-efficacy, anxiety, and metacognitive self-regulation changed from pretest to posttest as a function of group. Results from the analyses revealed a significant main effect of cognition/affect, $F (2, 238) = 39.78$, $p < .05$, $\eta^2 = .25$, and significant cognition/affect x gender, $F (2, 238) = 3.76$, $p < .05$, $\eta^2 = .03$, cognition/affect x feedback, $F (6, 238) = 2.27$, $p < .05$, $\eta^2 = .05$, cognition/affect x time x gender, $F (6, 238) = 2.38$, $p < .05$, $\eta^2 = .02$, and cognition/affect x time x feedback, $F (6, 238) = 1.94$, $p < .05$, $\eta^2 = .05$, interactions.

We then conducted paired samples t-tests as a function of goal condition and gender to explore which groups differed from pretest to posttest on each of the cognitive/affect variables. Results demonstrated that both female and male students in the control group had a significant decrease in self-efficacy, $t(15) = 2.14$, $p < .05$, and $t(7) = 2.17$, $p < .05$. Moreover, males in the control group had a significant increase in anxiety, $t(7) = -3.02$, $p < .05$. In contrast, female students in the performance-approach group had significant decreases in anxiety, $t(23) = 1.73$, $p < .05$, and metacognitive self-regulation, $t(23) = 2.45$, $p < .05$. No other differences were found.

Effects of Goal Condition on Student Retention

To explore whether goal condition influenced student retention, we examined the number of students who were placed on probationary status, which served as a proxy for retention. For the control group, 12.5% of the students were placed on probationary status, whereas for the experimental groups, 3%, 5.3%, and 7.7% for the mastery, performance-approach, and combined groups, respectively, were placed on probationary status.

Discussion

Results from the first study supported some of our hypotheses. Although there were no pretest differences on any of the variables at the beginning of the semester, significant posttest differences across groups were found at the end of the semester. Specifically, students in all three experimental conditions had higher levels of self-efficacy at the end of the semester compared to students in the control group. For the control group, both males' and females' level of self-efficacy dropped significantly from pretest to posttest. Moreover, students in the mastery goal and performance-approach goal conditions had significantly lower levels of anxiety at the end of the semester compared to students in the control group. In particular, male students in the control group experienced significant increases in levels of anxiety from the beginning of the semester to the end of the semester, whereas female students in the performance-approach group had significant decreases in anxiety and increases in levels of metacognitive self-regulation.

Accordingly, we argue that receiving feedback that includes more than raw performance scores is more beneficial for students' motivation than receiving raw scores alone. Interestingly, with respect to the normative goals perspective versus the multiple goals perspective, results from Study 1 do not provide support for either theoretical position. The normative goals perspective would predict that students in the mastery condition would benefit in terms of levels of motivation, whereas students in the performance-approach condition would benefit in terms of academic performance. In contrast, the multiple goals perspective would predict that students in the combined condition would receive the most benefit for motivation as well as performance. In contrast to these two predictions, for Study 1, students in the performance-approach goal condition benefited equally in terms of increasing levels of motivation compared to students in the mastery goal condition, whereas students in the combined condition benefited less than students in the other two goal conditions.

To explore the effects that each goal condition had on students' personal achievement goal orientations, we found that for the mastery goal condition, male students had significant decreases in their levels of performance-approach orientation from pretest to posttest. In contrast, female students in the combined condition experienced increases in their personal performance-avoidance orientations. Finally, no differences were found between groups on student retention. To examine whether these results were replicable, we conducted a similar study with students in another required first-year chemistry course.

Study 2

Participants

One hundred fifty-nine undergraduate university students enrolled in a required first-year inorganic chemistry course for science majors consented to participate in the study (N = 64 females). The mean age was 20.30 (SD = 3.55) and the mean self-reported high school GPA was 3.67 (out of a 4.50, SD = .52). Like Study 1, because of the repeated nature of the study, a number of students' data were not usable due to attrition. To ensure there were no differences between the two groups, we conducted a MANOVA on all variables. Results revealed a significant overall multivariate F, (Pillai's trace = .98, $F(8, 102) = 2.18$, $p > .05$), however univariate tests revealed no differences between groups with the exception of students' final grade, $F(1, 109) = 12.02$, $p < .05$ (students who dropped from the study had a final grade that was 11 points less than students who completed the study). We then compared final grade as a function of experimental condition for the dropout group. No differences were found.

Accordingly, the final sample size was 102 (N = 42 females), with a mean age of 20.29 (SD = 3.97) and mean self-reported high school GPA of 3.75 (SD = .50). Moreover, 73% of the final sample was majoring in biology, biochemistry, or chemistry.

Materials and Procedure

With the exception of the prior knowledge questionnaire, all materials and procedures for Study 2 were identical to those in Study 1. Prior knowledge questions for Study 2 are presented in Appendix C.

Results

Preliminary Analyses

Using a MANOVA, we first explored whether there were any treatment group differences at pretest on prior knowledge, high school GPA, self-efficacy, anxiety, metacognitive self-regulation, mastery goals, performance-approach goals, and performance-avoidance goals. Multivariate results (MANOVA) revealed no differences between groups on any of these variables (Pillai's trace = .19, $F(21, 282) = .93$, $p > .05$). We then assessed for differences on these variables as a function of gender. Independent samples t-test results revealed significant gender differences on metacognitive self-regulation and personal mastery goal orientation. Accordingly, gender was used as a covariate for subsequent relevant analyses. All means, standard deviations, and reliability coefficients are presented in Tables 7 through 10. Figures are also presented for comparative purposes.

Table 7. *Descriptive Statistics and Reliability Coefficients for All Variables*

	Pretest			Posttest		
	Mean	SD	α	Mean	SD	α
Prior Knowledge Score	1.78	1.22	-	-	-	-
High School GPA	3.75	.50	-	-	-	-
Final Grade (%)	-	-	-	75.28	12.49	-
Self-Regulation Variables[b]						
Self-Efficacy	5.54	1.11	.93	4.70	1.32	.94
MSR	4.90	.98	.85	4.30	1.00	.84
Anxiety	3.74	1.44	.80	3.84	1.39	.80
Personal Goal Orientations[c]						
Mastery Goal	4.49	.77	.93	4.06	.90	.91
Performance-Approach Goal	2.22	1.02	.89	2.26	1.06	.91
Performance-Avoid Goal	2.25	.92	.78	2.25	1.02	.85

Note: SD = standard deviation, MSR = metacognitive self-regulation, [a] N = 102, [b]1-7 point scale, [c]1-5 point scale

Table 8. *Descriptive Statistics for Prior Knowledge, GPA, and Final Grade by Condition*

	N	Mean	SD
Prior Knowledge			
Control	21	1.86	1.15
Mastery	28	2.04	1.20
Performance	23	1.52	1.31
Combined	30	1.70	1.21
High School GPA			
Control	20	3.63	.46
Mastery	26	3.84	.48
Performance	21	3.75	.53
Combined	27	3.76	.53
Final Grade			
Control	21	73.81	15.28
Mastery	28	75.64	13.05
Performance	23	76.69	12.37
Combined	30	74.89	10.23

Note: SD = standard deviation

Table 9. *Descriptive Statistics for SRL[a] Variables by Condition*

		Pretest		Posttest	
	N	Mean	SD	Mean	SD
Self-Efficacy[b]					
Control	21	5.36	1.15	4.68	1.50
Mastery	28	5.72	1.15	4.89	1.22
Performance	23	5.66	1.09	5.07	1.31
Combined	30	5.40	1.07	4.27	1.20
Metacognitive Self-Regulation[b]					
Control	21	4.91	.90	4.33	.99
Mastery	28	4.77	1.11	4.41	1.18
Performance	23	4.96	1.03	4.23	1.00
Combined	30	4.97	.92	4.22	.84
Anxiety[b]					
Control	21	3.89	1.74	3.82	1.58
Mastery	28	3.76	1.43	4.01	1.34
Performance	23	3.68	1.50	3.36	1.36
Combined	30	3.67	1.22	4.05	1.31

Note: SD = standard deviation, [a] SRL = self-regulated learning, [b]1-7 point scale

Table 10. *Descriptive Statistics for Goal Orientations by Condition*

		Pretest		Posttest	
Variables	N	Mean	SD	Mean	SD
Mastery Goal[a]					
Control	21	4.70	.50	4.11	.95
Mastery	28	4.41	.91	3.89	1.08
Performance	23	4.51	.63	3.99	.83
Combined	30	4.40	.86	4.22	.72
Performance-Approach Goal[a]					
Control	21	2.03	.85	2.25	1.09
Mastery	28	2.44	1.23	2.42	1.03
Performance	23	2.07	.81	2.30	1.16
Combined	30	2.26	1.04	2.11	1.00
Performance-Avoid Goal[a]					
Control	21	2.39	.84	2.24	.95
Mastery	28	2.29	1.00	2.35	1.07
Performance	23	2.08	.86	2.33	1.13
Combined	30	2.24	.97	2.11	.95

Note: SD = standard deviation, [a] 1-5 point scale

Figure 13

Figure 14

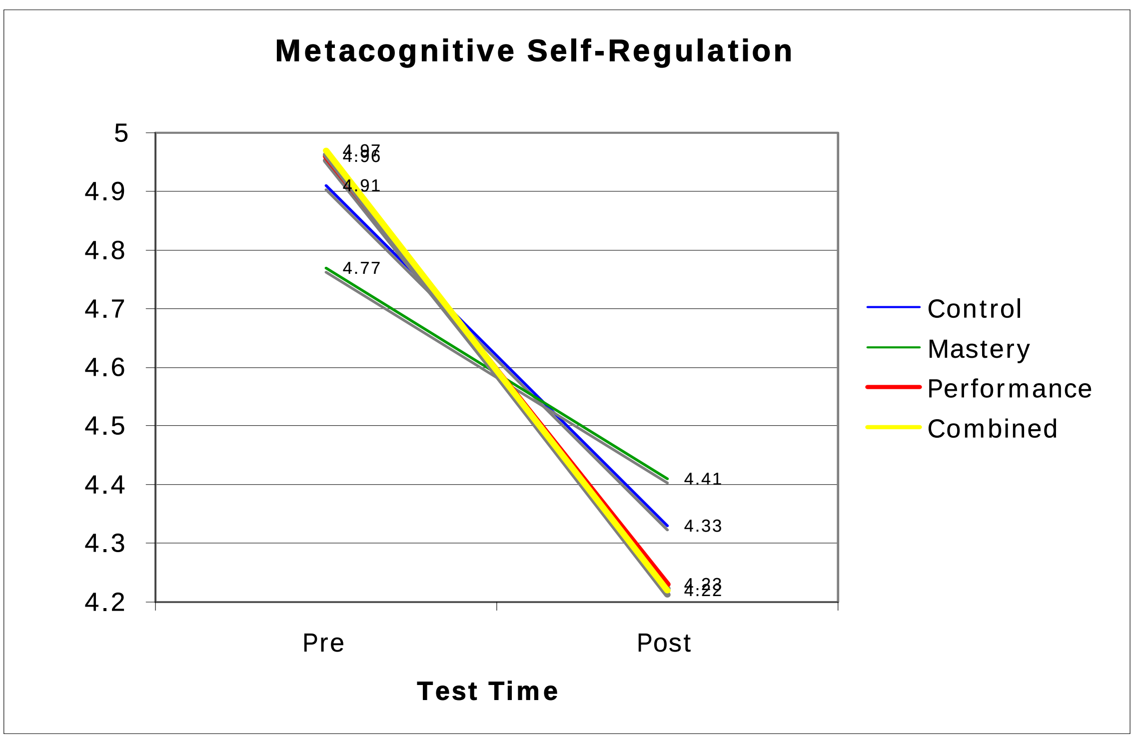


Figure 15

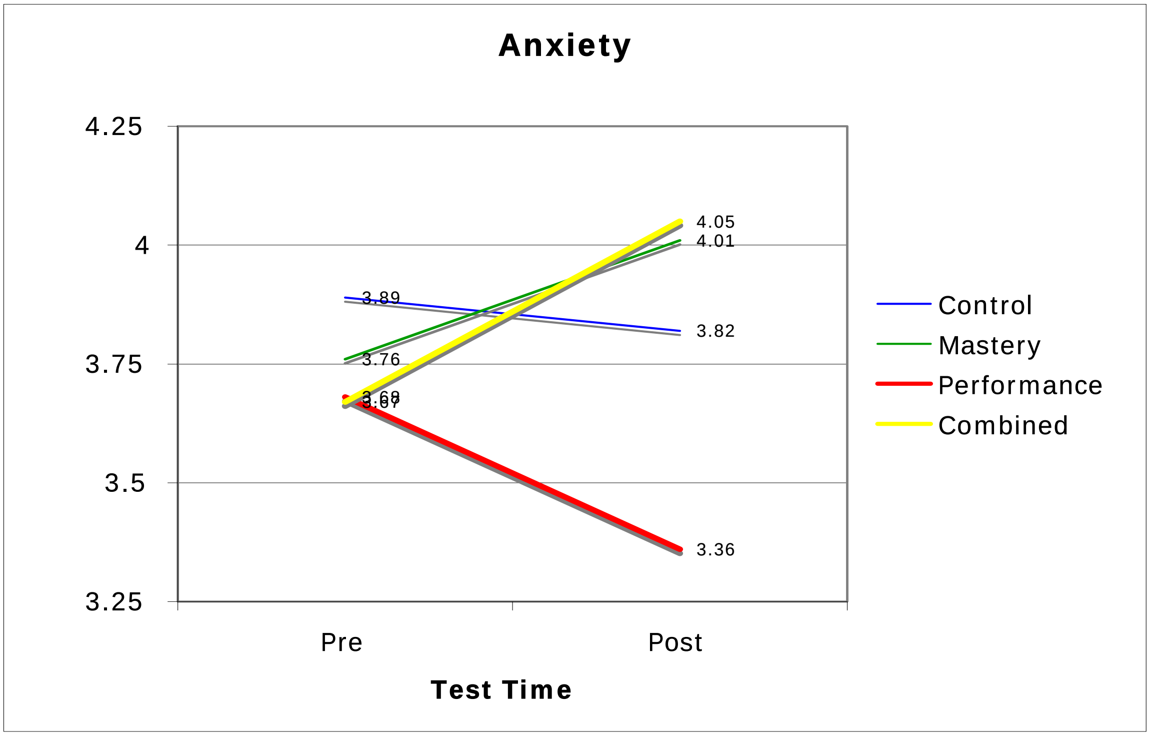


Figure 16

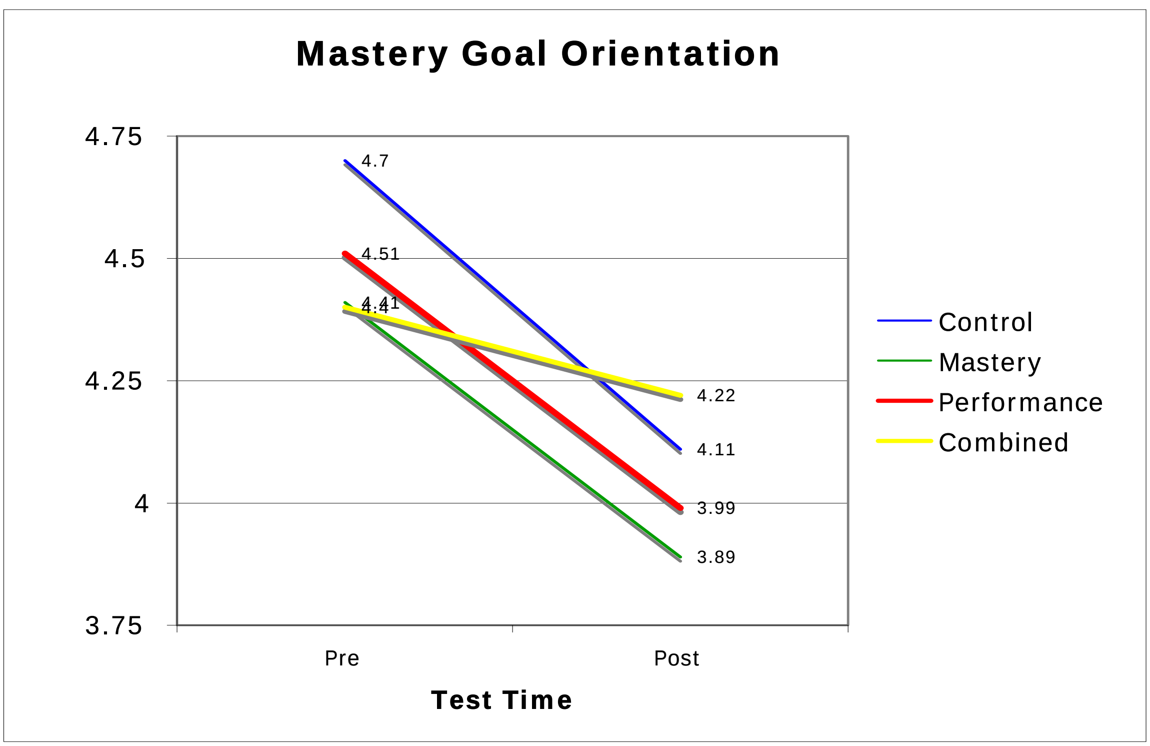


Figure 17

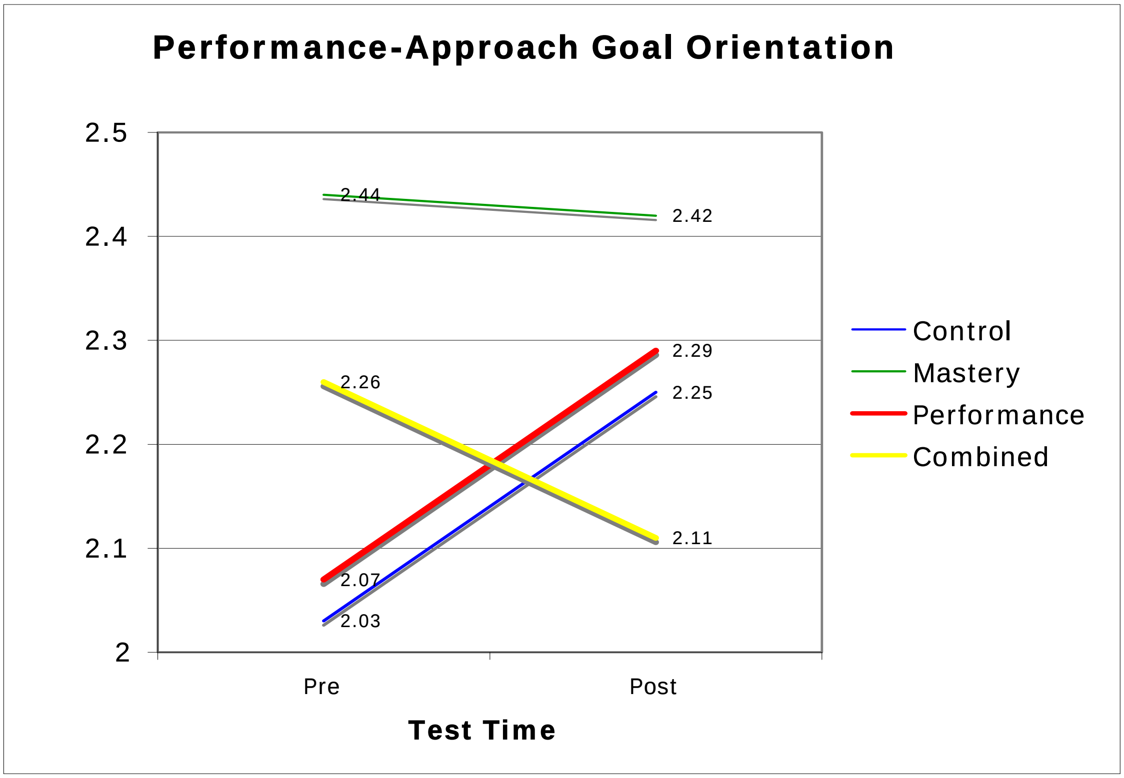
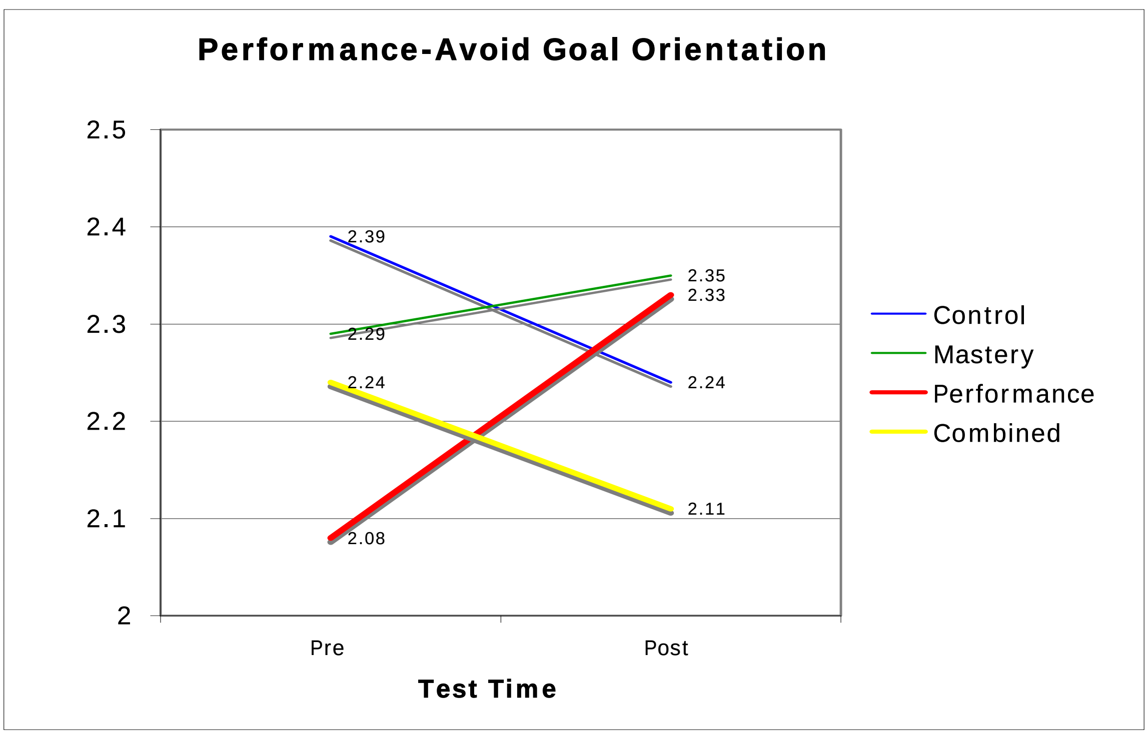


Figure 18



Effects of Goal Condition on Posttest Outcomes Across Groups

To examine the effects of the goal conditions on students' academic performance (final grade), self-efficacy, anxiety, metacognitive self-regulation, mastery goal, performance-approach goal, and performance-avoidance goal, a multivariate analysis of covariance (MANCOVA) was conducted, with gender as the covariate and goal condition (control, mastery, performance-approach, and mastery/performance-approach) as the independent variable. No significant omnibus F was found, $F(21, 273) = .94$, $p > .05$. Accordingly, no other statistical analyses were conducted.

Effects of Goal Condition Within Groups

To examine the effects that the feedback conditions had on students' personal goal orientations at posttest, we conducted a repeated measures analysis of covariance, with gender as the covariate. Results revealed a significant main effect of goal, $F(2, 190) = 175.16$, $p < .05$, $\eta^2 = .65$, a main effect of time, $F(1, 95) = 3.40$, $p < .01$, $\eta^2 = .06$, and goal x time, $F(2, 190) = 4.80$, $\eta^2 = .05$, $p < .01$, and goal x time x gender, $F(2, 190) = 2.15$, $p < .05$, $\eta^2 = .06$, interactions.

Based on these results, we conducted paired samples t-tests as a function of goal condition and gender to explore which groups differed from pretest to posttest on each of the achievement goal orientations. Of particular interest, both males and females in the control group experienced a significant decrease in mastery orientation from pretest to posttest, $t(11) = 2.53$, $p < .05$, and $t(7) = 2.78$, $p < .05$, respectively. For the mastery group, males experienced a significant decrease in mastery orientation, $t(16) = 3.05$, $p <.05$, as did males in the performance-approach condition, $t(12) = 2.83$, $p < .05$. Finally, for the combined condition, females experienced a significant decrease in mastery orientation from pretest to posttest, $t(13)$ 3.07, $p < .01$. Means and standard deviations are presented in Tables 11 and 12, and Figures are presented for comparative purposes.

Table 11. *Descriptive Statistics for SRL Variables by Condition x Gender*

	N		Pretest Mean (SD)		Posttest Mean (SD)	
	F	M	F	M	F	M
Self-Efficacy[b]						
Control	8	12	4.89 (1.04)	5.66 (1.20)	3.95 (1.24)	5.10 (1.58)
Mastery	10	17	5.90 (1.46)	5.58 (.98)	4.68 (1.57)	5.07 (1.01)
Performance	10	13	5.48 (.98)	5.81 (1.19)	4.84 (1.40)	5.24 (1.27)
Combined	14	16	5.50 (1.33)	5.31 (.81)	4.12 (1.40)	4.40 (1.02)
Metacognitive Self-Regulation[b]						
Control	8	12	4.65 (.83)	5.04 (.96)	4.02 (.85)	4.43 (1.04)
Mastery	10	17	5.78 (.93)	4.21 (.77)	5.19 (1.38)	3.98 (.83)
Performance	10	13	4.99 (.93)	4.93 (1.14)	4.22 (.96)	4.24 (1.07)
Combined	14	16	5.26 (.83)	4.72 (.94)	4.30 (.61)	4.15 (1.02)
Anxiety[b]						
Control	8	12	4.35 (1.96)	3.47 (1.59)	4.48 (1.52)	3.28 (1.52)
Mastery	10	17	4.34 (1.75)	3.52 (1.14)	4.74 (1.24)	3.59 (1.29)
Performance	10	13	4.02 (1.55)	3.42 (1.47)	3.48 (1.42)	3.26 (1.37)
Combined	14	16	3.61 (1.20)	3.73 (1.27)	4.14 (1.37)	3.98 (1.28)

Note: SD = standard deviation, F = female, M = male, [b]1-7 point scale.

Table 12. *Descriptive Statistics for Goal Orientations by Condition x Gender*

	N		Pretest Mean (SD)		Posttest Mean (SD)	
	F	M	F	M	F	M
Mastery Goal[a]						
Control	8	12	4.70 (.70)	4.67 (.37)	4.08 (1.30)	4.10 (.75)
Mastery	10	17	4.74 (.60)	4.18 (1.03)	4.38 (1.09)	3.66 (1.02)
Performance	10	13	4.54 (.60)	4.49 (.69)	4.04 (.92)	3.95 (.79)
Combined	14	16	4.91 (.23)	3.95 (.97)	4.46 (.50)	4.01 (.83)
Performance-Approach Goal[a]						
Control	8	12	2.03 (1.01)	2.12 (.74)	2.25 (1.40)	2.33 (.90)
Mastery	10	17	2.56 (1.60)	2.28 (.96)	2.26 (1.12)	2.48 (1.02)
Performance	10	13	1.90 (.70)	2.20 (.90)	2.02 (1.34)	2.51 (1.00)
Combined	14	16	1.97 (1.01)	2.51 (1.04)	1.69 (.65)	2.48 (1.12)
Performance-Avoid Goal[a]						
Control	8	12	2.72 (.94)	2.21 (.77)	2.41 (1.16)	2.17 (.86)
Mastery	10	17	2.53 (1.50)	2.18 (.62)	2.23 (1.23)	2.35 (.99)
Performance	10	13	1.93 (.70)	2.19 (.98)	2.25 (1.22)	2.38 (1.10)
Combined	14	16	1.93 (.98)	2.52 (.89)	1.70 (.77)	2.47 (.97)

Note: SD = standard deviation, F = female, M = male, [a] 1-5 point scale

Figure 19

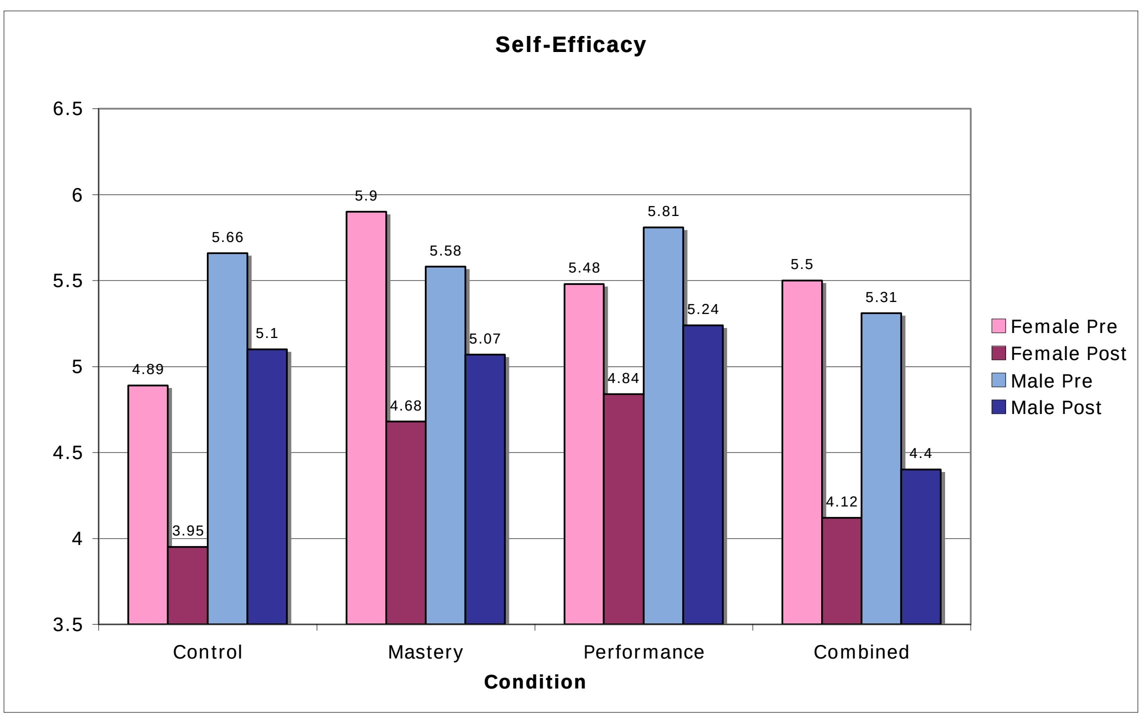


Figure 20

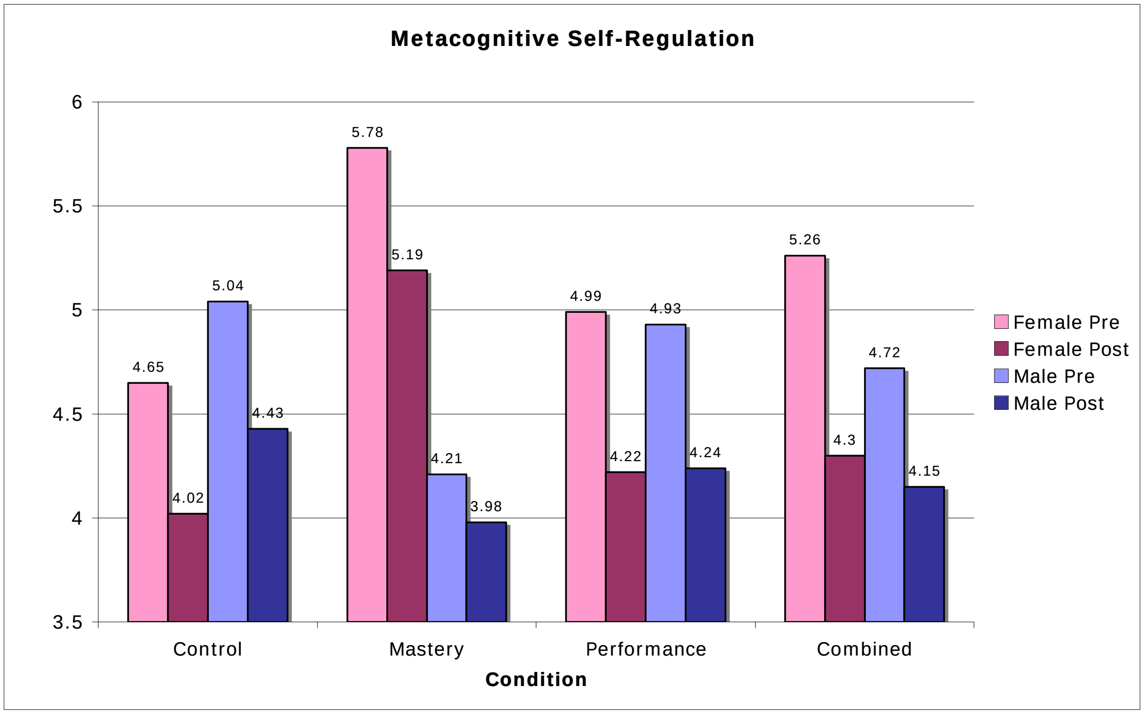


Figure 21

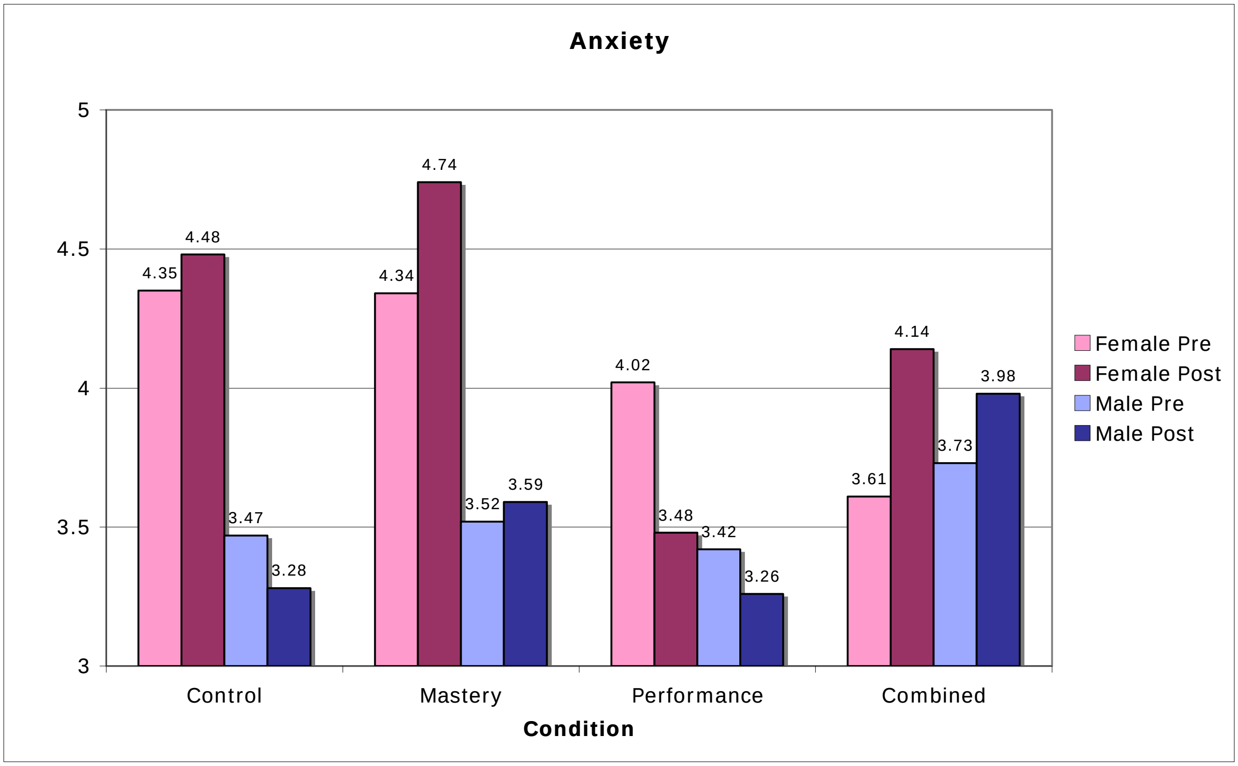


Figure 22

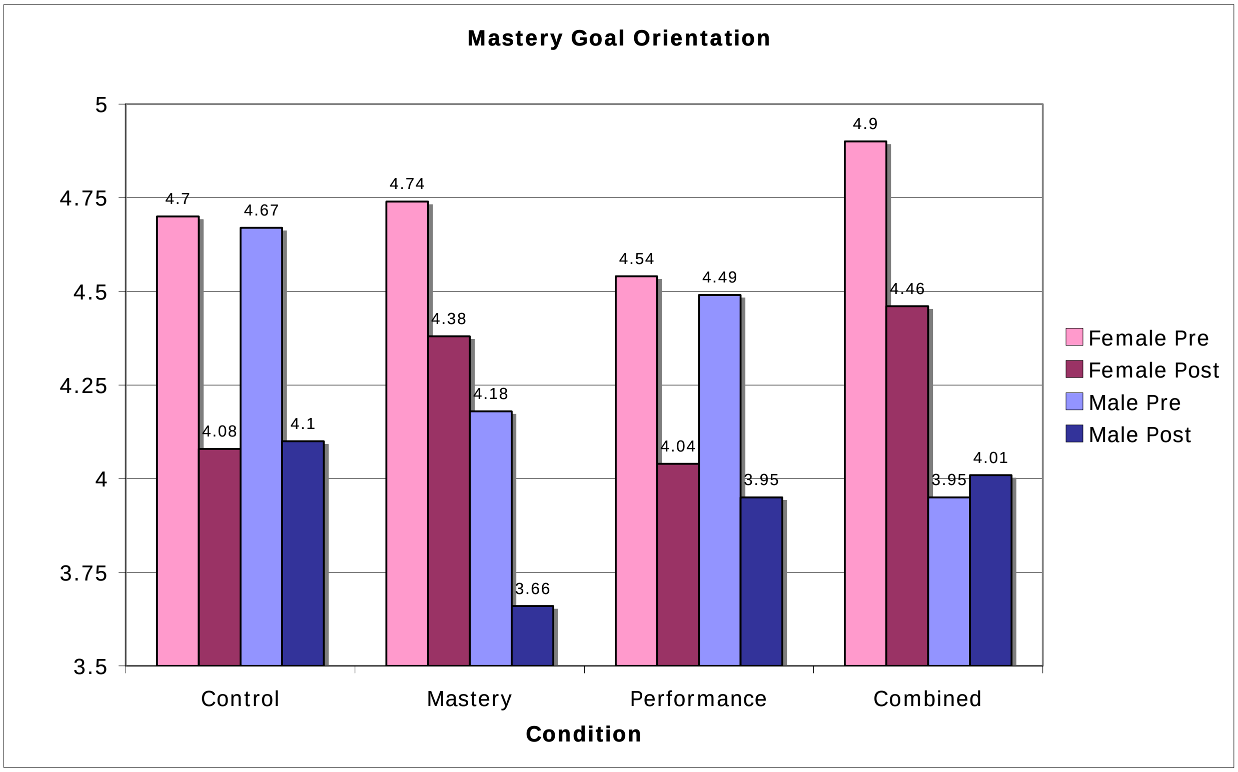


Figure 23

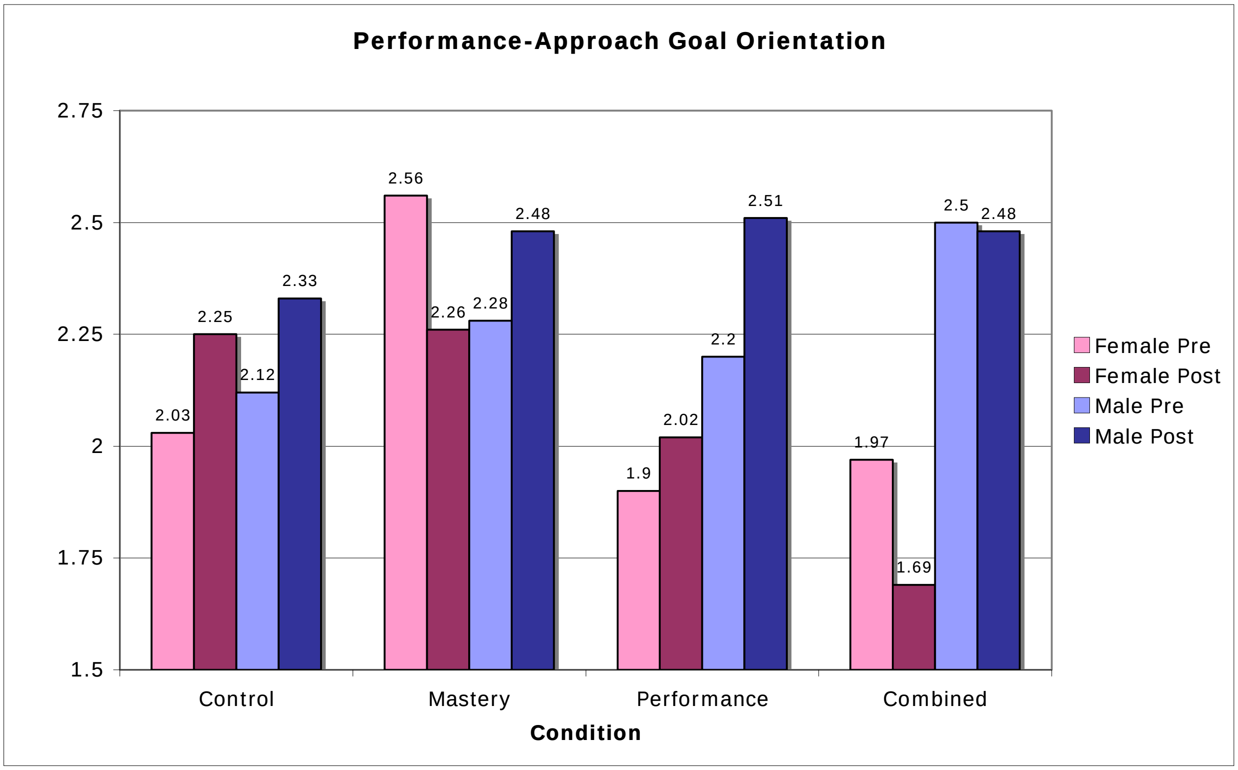
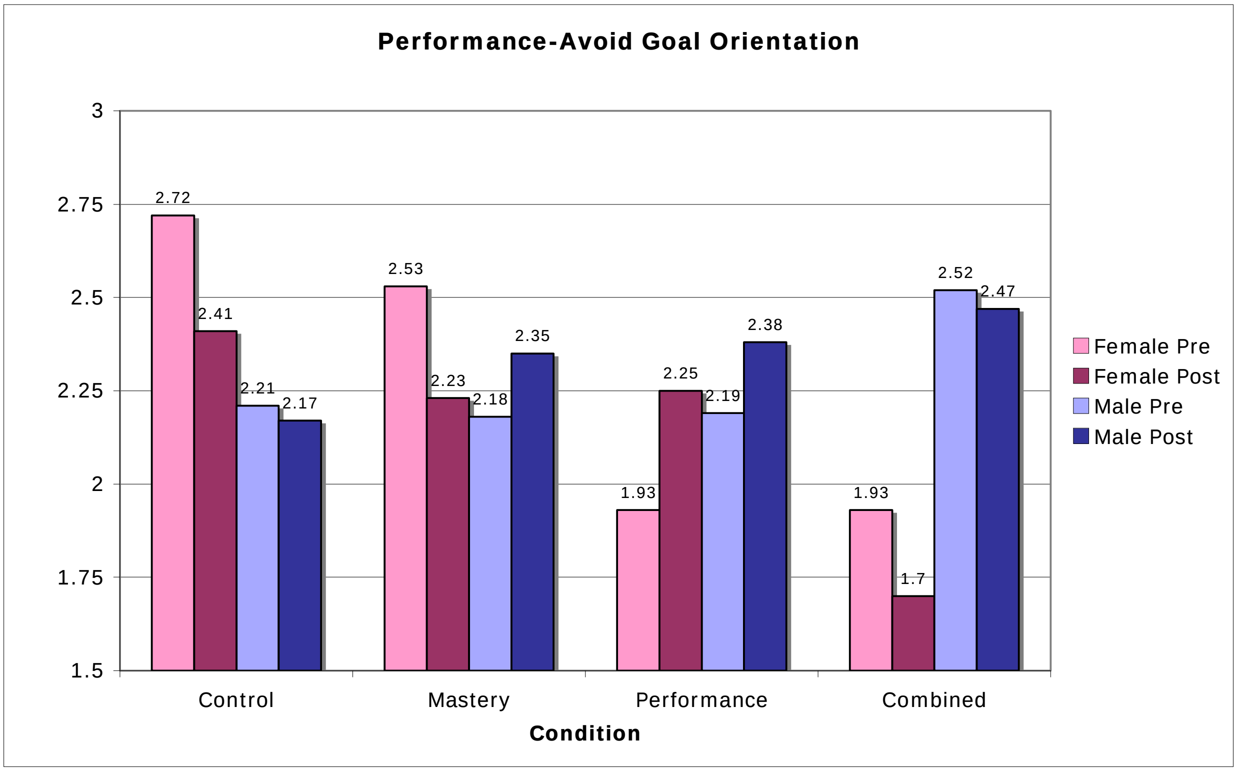


Figure 24



Similar analyses were carried out for self-efficacy, anxiety, and metacognitive self-regulation ("cognition/affect") to explore pretest/posttest differences as a function of group. A repeated measures analysis of variance was conducted to assess whether students' self-efficacy, anxiety, and metacognitive self-regulation changed from pretest to posttest as a function of group. Results from the analyses revealed a significant main effect of cognition/affect, $F (2, 190) = 6.96$, $p < .01$, $\eta^2 = .07$, a main effect of time, $F (1, 95) = 20.10$, $p < .01$, $\eta^2 = .18$, and cognition/affect x gender, $F (2, 190) = 4.11$, $p < .05$, $\eta^2 = .04$, cognition/affect x time, $F (2, 190) = 17.64$, $\eta^2 = .16$, and cognition/affect x time x feedback, $F (2, 190) = 2.14$, $p < .05$, $\eta^2 = .06$ interactions.

We then conducted paired samples t-tests as a function of goal condition and gender to explore which groups differed from pretest to posttest on each of the cognitive/affect variables. Both males and females in the control group significantly decreased their levels of self-efficacy, $t (7) = 2.01$, $p < .05$, and $t (11) = 1.89$, $p < .05$, respectively, and their metacognitive self-regulation from pretest to posttest, $t(7) = 3.05$, $p < .05$, and $t(11) = 3.83$, $p < .01$, respectively. For the mastery group, both males' and females' level of self-efficacy decreased significantly from pretest to posttest, $t(16) = 2.63$, $p < .01$, and $t(9)$ 2.91, $p < .01$, respectively. Similarly, for students in the performance-approach group, both males' and females' level of self-efficacy decreased, $t(12) = 1.90$, $p < .05$, and $t(9) = 1.79$, $p < .05$, respectively. Moreover, males in the performance-approach group significantly decreased their levels of metacognitive self-regulation from pretest to posttest, $t(12) = 2.66$, $p < .05$. Finally, in the combined condition, males and females experienced decreased levels of self-efficacy, $t(15) = 3.53$, $p < .05$, and $t(13) = 4.20$, $p < .05$, respectively, and metacognitive self-regulation, $t(15) = 4.02$, $p < .05$, and $t(13) = 3.42$, $p < .05$, respectively, and females' level of anxiety significantly increased, $t(13) = -2.04$, $p < .05$. No other significant results were found.

Effects of Goal Condition on Student Retention

To explore whether goal condition influenced student retention, we examined the number of students who were placed on probationary status. For the control group, 23.8% of the students were placed on probationary status, whereas for the experimental groups, 14.4%, 13%, and 10% for the mastery, performance-approach, and combined groups, respectively, were placed on probationary status.

Discussion

Unlike Study 1, no differences were found on any of the outcome variables between groups at posttest. We speculate two potential reasons for the lack of significant results for this study. First, there was insufficient power to detect differences between groups due to the small sample sizes. Second, it is possible that the interventions in each group were not effective in influencing student outcomes. Moreover, an examination of the changes within groups suggests all groups decreased in personal mastery orientation and self-efficacy over time, and that most groups decreased in metacognitive self-regulation, with females in the combined group experiencing increases in anxiety.

To help explain these results, we turn to previous research that has examined the stability of achievement goal orientation over the course of an undergraduate semester. In particular, although few studies have examined the nature of stability and change in undergraduate students' personal achievement goal orientations, studies that have been conducted have all shown significant decreases in students' mastery goals, with less change in performance-approach and performance-avoidance goals (Fryer & Elliot, 2007; Muis & Edwards, 2009; Senko & Harackiewicz, 2005; Winne et al., 2005). Results from this study are consistent with these outcomes in that, regardless of goal condition, students' personal mastery goals significantly decreased over the course of the semester. This may suggest that the intervention was not enough to influence student outcomes (Linnenbrink, 2005). We elaborate these possibilities in our general discussion.

General Discussion

The purpose of this series of studies was to explore the effects that manipulating feedback has on students' personal achievement goals, their motivation and affect for learning science content, as well as their achievement and retention in first-year undergraduate chemistry courses. Results from the first study partially supported our hypotheses, whereas results from the second study suggested the intervention had no effect on student outcomes, or sample sizes were too small to detect any significant changes in outcomes. Due to the null effects of the second study, we focus primarily on results from the first study for the general discussion. We first consider the debate over the multiple versus normative goals perspective, followed by the effects that each treatment had on the outcomes and changes that occurred from pretest to posttest. We then discuss the educational implications of this series of studies, and conclude with limitations and directions for future research.

The Normative Versus Multiple Goals Perspective

Over the past decade, achievement goal theorists have debated whether performance-approach goals are beneficial or detrimental for learning. Given the variability in outcomes across a multitude of studies, researchers have suggested that performance-approach goals have both positive and negative effects on learning (e.g., Elliot & Moller, 2003). Researchers have also argued that performance-approach goals can be beneficial when coupled with mastery goals (Pintrich, 2000a). Whether mastery goals alone or a combination of both mastery and performance-approach goals are most beneficial across a number of outcomes has been at the heart of the debate. These two positions have been coined the normative goals perspective versus the multiple goals perspective (Pintrich 2000a).

To examine these two competing theoretical positions, we explored whether students in a mastery goal oriented feedback condition experienced more gains compared to students in a performance-approach condition, a combined mastery/performance-approach condition, and a control condition. According to Linnenbrink (2005), the normative goals perspective would predict that students in the mastery goal condition would have higher self-efficacy, higher metacognitive self-regulation, higher levels of achievement and retention, and lower anxiety compared to the other three groups. In contrast, the multiple goals perspective would predict equivalent levels of self-efficacy and metacognitive self-regulation between the mastery and combined conditions, with the performance-approach condition espousing low levels of self-efficacy and moderate levels of metacognitive self-regulation. Similarly, individuals in the mastery and combined conditions would experience low levels of anxiety, whereas individuals in the performance-approach condition would experience high levels of anxiety. Finally, the multiple goals perspective would predict only moderate levels of achievement and slightly lower levels of retention in the mastery group compared to students in the performance-approach and combined conditions.

Results from our study provide contradictory support for both theoretical positions. Specifically, results from the achievement data provide support for the normative goals perspective; students in the mastery goal condition had lower levels of performance compared to students in the performance-approach and combined conditions, but all three had higher levels of performance compared to the control group. In contrast, students in the mastery and performance-approach conditions had the highest levels of self-efficacy at posttest, followed by the combined condition. For metacognitive self-regulation, the combined condition had the highest level followed by equivalent levels between the mastery and performance-approach conditions. Finally, for levels of anxiety, the mastery group experienced the lowest levels of anxiety, followed by the performance-approach and combined groups, with the control group experiencing the highest levels of anxiety. Based on these results, we argue that neither theoretical position is supported. Rather, it appears that providing students with feedback that includes more than a raw performance score is more beneficial than a raw score alone.

The positive influence that feedback has on students' cognitive and affective factors is consistent with predictions from contemporary models of self-regulated learning (e.g., Muis, 2007; Pintrich, 2000b; Winne & Hadwin, 1998; Zimmerman, 1998). In the context of learning, feedback serves as a source of information that individuals may use to gauge whether one has achieved his or her learning goals, or whether one must adjust goals, strategies, or motivation to better achieve those goals (Muis, 2007). For example, as individuals work on a task, information is generated or copied to working memory that can serve as feedback (Butler & Winne, 1995). If the learner monitors the profile of products created during learning, and compares those products to the goals he or she initially sets for learning, then internal feedback is generated. Moreover, if a product is observable (e.g., a product created for an exam or assignment), then external feedback may be available if an external source, such as a teacher, responds to the learner's behaviour. This feedback can be used to judge whether the set goals have been achieved; if not, the information produced from monitoring may be used to adjust or redefine an individual's learning goals, types of learning strategies to use, or future motivation on subsequent similar learning tasks.

In the context of our research, with the exception of the control group, students received a raw performance score as well as information regarding whether they improved their understanding of course content (mastery group), how well they performed compared to other students (performance-approach group), or a combination of improvement in understanding as well as performance compared to others (combined condition). This additional feedback benefited all three experimental groups; students' self-efficacy in the experimental groups at the end of the semester was significantly higher than students' self-efficacy in the control group. Moreover, students in the mastery goal condition and performance-approach goal condition had lower levels of anxiety for learning course content. Trends in the data also suggest that receiving additional feedback increased student retention as students in the control group had the highest level of probationary status. Accordingly, we posit that providing some form of feedback that is more than a raw performance score benefits students' motivation and affect. Theoretically, this additional source of feedback information may foster further metacognitive monitoring of goal standards, affect, and motivation (Muis, 2007).

The Effects of Classroom Goal Structures on Personal Achievement Goals

Previous research that has examined the effects that classroom goal structures have on students' personal achievement goals, self-regulatory strategies, self-efficacy, and achievement has typically found that a combined mastery and performance-approach classroom goal orientation is related to students' adoption of mastery and performance-approach goals (e.g., Linnenbrink, 2005; Roeser, Midgley, & Urdan, 1996; Urdan, 2004; Urdan & Midgley, 2003). These studies have also found that a combined mastery and performance-approach classroom condition increases students' motivation (e.g., self-efficacy), emotional well being, cognitive engagement, help seeking, and achievement (e.g., Ames & Archer, 1988; Kaplan & Midgley, 1999; Roeser et al., 1996). Based on these previous studies, we hypothesized that students in the mastery group would experience increases in mastery orientation and decreases in performance-approach orientation, whereas students in the performance-approach group would experience decreases in mastery orientation and increases in performance-approach orientation. Finally, we expected that students in the combined condition would experience increases in both mastery and performance-approach goals.

Results from our study partially supported these hypotheses. Rather than finding an increase in students' personal mastery goals, students in the mastery group experienced decreases in their personal performance-approach and performance-avoidance goals. We find these results noteworthy. In particular, several of the studies that have examined the influence that changes in classroom goal structures have on various student outcomes have typically focused on elementary or middle school students (e.g., Linnenbrink, 2005; Urdan & Midgley, 2003). To date, we know of no studies that have been conducted at the university level. Moreover, recent studies that have examined the stability of undergraduate students' achievement goal orientations have found significant decreases in students' mastery goals (e.g., Fryer & Elliot, 2007; Muis & Edwards, 2009; Senko & Harackiewicz, 2005). From these studies, one may infer students' mastery goals decrease over the course of the semester, even in classrooms that are primarily mastery oriented (Muis & Edwards, 2009). In our study, students' mastery goals were resilient to change when feedback included more than raw performance data, regardless of the focus of that feedback. These results have important educational implications, which we discuss next.

Educational Implications

Given the increasing demands for scientists (NSB, 2006) and the growing concerns of the dropout rates for undergraduate students enrolled in the sciences (Daempfle, 2004), it is pertinent that educators implement classroom interventions that foster student learning, motivation, and achievement. We responded to this pressing concern by implementing a system in an online environment that manipulated the types of feedback students received on their course quizzes. Our goal was to create different learning environments that mirrored the types of classroom goal structures that researchers suggest might foster improved learning, motivation, and achievement. By creating environments that potentially increase student learning, we aimed to increase student retention in first-year undergraduate chemistry courses.

Although our sample sizes were small and differences were not statistically detectable, the control group, in which students did not receive feedback on course quizzes other than a raw performance score, had higher rates of students on probationary status than the three treatment groups. To interpret this outcome, we highlight that students in the treatment groups had higher self-efficacy and lower levels of anxiety at the end of the semester compared to students in the control group. Based on these results, we infer that the additional feedback that students received in the treatment groups fostered students' self-efficacy and lowered their anxiety, which subsequently led to increases in student learning.

Accordingly, we posit that our intervention holds great promise in addressing student retention at the undergraduate level of education. Specifically, provincially or state-funded colleges and universities in North America typically have large first-year undergraduate enrollments in the sciences and mathematics[1]. Given the large number of students in these courses, it is particularly challenging for professors to provide immediate feedback and feedback that provides more than raw score information. In a time of budget cuts and reductions in teaching assistantships, professors are left to grapple with large amounts of grading and little time to complete it. By implementing a system that provides students immediate feedback on their performance coupled with information that focuses on understanding and improvement, comparative performance, or both, there is more opportunity for students to learn from that immediate feedback, which may subsequently improve student outcomes (Muis, 2007; Winne & Hadwin, 1998).

Limitations and Future Directions

Although some interesting patterns of results emerged from our research, results must be interpreted with caution, as there are a number of limitations that need to be addressed. First, our sample sizes were small given the high attrition rates over the course of the semester. Interestingly, students who had the tendency to drop out from the study were those whose grades were particularly low. Given the focus of our study on retention, it is disappointing that the target

[1] For example, each year there are approximately 800 students enrolled in a required first-year calculus course at McGill University. There are only five professors teaching this course and no teaching assistants. Similar numbers are reported for other first-year mathematics and science classes at McGill and at other universities.

group of interest was significantly diminished. Although interactions have not occurred in previous research similar in nature to ours (e.g., Linnenbrink, 2005), we cannot completely rule out the possibility that different effects may occur with "low achieving" students.

Second, we were not able to collect student retention data. Rather, we used a proxy, student probationary status, to measure student retention. Although students on probationary status are more likely to drop out than students who are not placed on probationary status (Kirby & Sharpe, 2001; McGrath & Braunstein, 1997), it is important for future research to gain access to student drop-out information after completion of the study. Currently, we are in the process of gaining access to the drop-out data for this cohort.

Finally, given the lack of remarkable results from the second study, it is pertinent to assess the effectiveness of the intervention in future studies. In particular, we plan to assess treatment fidelity by directly asking students about the nature of the feedback they received, their perceptions about that feedback, and whether and how the feedback influenced their thinking about their own learning. By better understanding whether and how students attended to the feedback, researchers may be able to develop instructional interventions that more effectively address students' needs in terms of bolstering their learning, motivation, and achievement. We anticipate exciting new directions along this line of work not only with students enrolled in science courses, but also for students enrolled in other courses from other disciplines including mathematics and the social sciences.

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Appendix A
Prior Knowledge Questionnaire for Study 1

1. An increase in the temperature of a solution usually… {Solutions}

decreases the solubility of a solid solute in the solution.
Increases the boiling point.
Decreases the solubility of a liquid solute in the solution.
Increases the solubility of a gas in the solution.
* increases the solubility of a solid solute in the solution.

2. The correct answer for the addition of 7.5 g + 2.26 g + 1.311 g + 2 g is ________. {Significant Figures}

13.071 g
* 13 g
13.0 g
10 g
13.1 g

3. A pure substance is matter with a composition that… {Properties of Matter}

always contains oxygen
• is fixed in a definite proportion at all times
always contains two or more substances
varies according to the amount of water present
depends on the temperature

4. Identify the metalloid in the following list. {Periodic Table}

sulfur (S)
• germanium (Ge)
silver (Ag)
copper (Cu)
fluorine (F)

5. The abbreviated electron configuration for a boron atom (Z=5) is ___________. {Electron Configuration}

• [He] 2s2 2p1
1s2 2s2 2p1
[Ne] 2s2 2p1
[H] 2s2 2p1
1s2 2s2 2p6

6. Gold (III) bromide has the following correct formula. {Formula Writing}

Au3Br
AuBr3
Au3Br2
AuBr
* Au3Br3

7. What is the coefficient of hydrogen, H2, when the following equation is balanced? {Chemical Equations}

Al + H2SO4 → Al2(SO4)3 + H2
• 3
5
2
1
4

8. The following reaction is an example of a ________ reaction. {Chemical Reaction Types}

2C2H6 + 7O2 -→ 4CO2 + 6H2O
single replacement
decomposition
double replacement
displacement
* combustion

9. When 2.50 mol of Mg3N2 are allowed to react according to the following equation, how many moles of H2O also react? {Stoichiometry}

Mg3N2 + 6H2O -→ 3Mg(OH)2 + 2NH3
1.25 mol
2.50 mol
9.00 mol
* 15.0 mol
6.00 mol

10. The volume of a gas with a pressure of 1.2 atm increases from 1.0 L to 4.0 L. What is the final pressure of the gas, assuming constant temperature? {Gas Laws}

1.0 atm
1.2 atm
4.8 atm
3.3 atm
* 0.30 atm

APPENDIX B

PATTERNS OF ADAPTIVE LEARNING SCALE

Here are some questions about yourself as a student in **this chemistry class**. Please **put an "x" directly beside the number** that best describes what you think.

If a statement is **very true** of you, put an "x" beside 5.
If a statement is **not at all true** of you, put an "x" beside 1.
If a statement is more or less true of you, put an "x" beside the number between 2 and 4 that best describes you.

1. It's important to me that I don't look stupid in chemistry class.

1	**2**	**3**	**4**	**5**
Not at all true		Somewhat true		Very true

2. It's important to me that other students in my class think I am good at my class work.

1	**2**	**3**	**4**	**5**
Not at all true		Somewhat true		Very true

3. It's important to me that I learn a lot of new concepts this year.

1	**2**	**3**	**4**	**5**
Not at all true		Somewhat true		Very true

4. One of my goals is to show others that I'm good at my chemistry class work.

1	**2**	**3**	**4**	**5**
Not at all true		Somewhat true		Very true

5. One of my goals in chemistry class is to learn as much as I can.

1	**2**	**3**	**4**	**5**
Not at all true		Somewhat true		Very true

6. One of my goals is to keep others from thinking I'm not smart in class.

1	**2**	**3**	**4**	**5**
Not at all true		Somewhat true		Very true

7. One of my goals is to master a lot of new skills this year.

1	**2**	**3**	**4**	**5**

Not at all true Somewhat true Very true

8. One of my goals is to show others that chemistry work is easy for me.

1	**2**	**3**	**4**	**5**
Not at all true		Somewhat true		Very true

9. It's important to me that I thoroughly understand my class work.

1	**2**	**3**	**4**	**5**
Not at all true		Somewhat true		Very true

10. One of my goals is to look smart in comparison to the other students in my chemistry class.

1	**2**	**3**	**4**	**5**
Not at all true		Somewhat true		Very true

11. One of my goals in class is to avoid looking like I have trouble doing the work.

1	**2**	**3**	**4**	**5**
Not at all true		Somewhat true		Very true

12. It's important to me that I look smart compared to others in my chemistry class.

1	**2**	**3**	**4**	**5**
Not at all true		Somewhat true		Very true

13. It's important to me that my teacher doesn't think that I know less than others in class.

1	**2**	**3**	**4**	**5**
Not at all true		Somewhat true		Very true

14. It's important to me that I improve my skills this year.

1	**2**	**3**	**4**	**5**
Not at all true		Somewhat true		Very true

APPENDIX C

MOTIVATED STRATEGIES FOR LEARNING QUESTIONNAIRE

The following questions ask about your study habits in your chemistry course(s). Remember, there are no right or wrong answers. Just answer as accurately as possible for you. Use the scale below to answer the questions.

If you think the statement is very true of you, circle 7.

If a statement is not at all true of you, circle 1.

If the statement is more or less true of you, circle the number between 1 and 7 that best describes you.

1	2	3	4	5	6	7
not at all true of me						very true of me

1.	In a class like this, I prefer course material that really challenges me so I can learn new things.	1	2	3	4	5	6	7
2.	If I study in appropriate ways, then I will be able to learn the material in this course.	1	2	3	4	5	6	7
3.	When I take a test I think about how poorly I am doing compared with other students.	1	2	3	4	5	6	7
4.	I think I will be able to use what I learn in this course in other courses.	1	2	3	4	5	6	7
5.	I believe I will receive an excellent grade in this class.	1	2	3	4	5	6	7
6.	I'm certain I can understand the most difficult material presented in the readings for this course.	1	2	3	4	5	6	7
7.	Getting a good grade in this class is the most satisfying thing for me right now.	1	2	3	4	5	6	7
8.	When I take a test I think about items on other parts of the test I can't answer.	1	2	3	4	5	6	7
9.	It is my own fault if I don't learn the material in this course.	1	2	3	4	5	6	7
10.	It is important for me to learn the material in this class.	1	2	3	4	5	6	7
11.	The most important thing for me right now is improving my overall grade point average so my main concern in this class is getting a good grade.	1	2	3	4	5	6	7
12.	I'm confident I can learn the basic concepts taught in this course.	1	2	3	4	5	6	7

13.	If I can, I want to get better grades in this class than most of the other students.	1	2	3	4	5	6	7
14.	When I take tests I think of the consequences of failing.	1	2	3	4	5	6	7
15.	I'm confident I can understand the most complex material presented by the instructor in this course.	1	2	3	4	5	6	7
16.	In a class like this, I prefer course material that arouses my curiosity, even if it is difficult to learn.	1	2	3	4	5	6	7
17.	I am very interested in the content area of this course.	1	2	3	4	5	6	7
18.	If I try hard enough, then I will understand the course material.	1	2	3	4	5	6	7
19.	I have an uneasy, upset feeling when I take an exam.	1	2	3	4	5	6	7
20.	I'm confident I can do an excellent job on the assignments and tests in this course.	1	2	3	4	5	6	7
21.	I expect to do well in this class.	1	2	3	4	5	6	7
22.	The most satisfying thing for me in this course is trying to understand the content as thoroughly as possible.	1	2	3	4	5	6	7
23.	I think the course material in this class is useful for me to learn.	1	2	3	4	5	6	7
24.	When I have the opportunity in this class, I choose course assignments that I can learn from even if they don't guarantee a good grade.	1	2	3	4	5	6	7
25.	If I don't understand the course material, it is because I didn't try hard enough.	1	2	3	4	5	6	7
26.	I like the subject matter of this course.	1	2	3	4	5	6	7
27.	Understanding the subject matter of this course is very important to me.	1	2	3	4	5	6	7
28.	I feel my heart beating fast when I take an exam.	1	2	3	4	5	6	7
29.	I'm certain I can master the skills being taught in this class.	1	2	3	4	5	6	7
30.	I want to do well in this class because it is important to show my ability to my family, friends, employer, or others.	1	2	3	4	5	6	7
31.	Considering the difficulty of this course, the teacher, and my skills, I think I will do well in this class.	1	2	3	4	5	6	7
32.	When I study the readings for this course, I outline the material to help me organize my thoughts.	1	2	3	4	5	6	7
33.	During class time I often miss important points because I'm thinking of other things.	1	2	3	4	5	6	7
34.	When studying for this course, I often try to explain the material to a	1	2	3	4	5	6	7

	classmate or friend.							
35.	I usually study in a place where I can concentrate on my course work.	1	2	3	4	5	6	7
36.	When reading for this course, I make up questions to help focus my reading.	1	2	3	4	5	6	7
37.	I often feel so lazy or bored when I study for this class that I quit before I finish what I planned to do.	1	2	3	4	5	6	7
38.	I often find myself questioning things I hear or read in this course to decide if I find them convincing.	1	2	3	4	5	6	7
39.	When I study for this class, I practice saying the material to myself over and over.	1	2	3	4	5	6	7
40.	Even if I have trouble learning the material in this class, I try to do the work on my own, without help from anyone.	1	2	3	4	5	6	7
41.	When I become confused about something I'm reading for in this class, I go back and try to figure it out.	1	2	3	4	5	6	7
42.	When I study for this course, I go though the readings and my class notes and try to find the most important ideas.	1	2	3	4	5	6	7
43.	I make good use of my study time for this course.	1	2	3	4	5	6	7
44.	If course readings are difficult to understand, I change the way I read the material.	1	2	3	4	5	6	7
45.	I try to work with other students from this class to complete the course assignments.	1	2	3	4	5	6	7
46.	When studying for this course, I read my class notes and the course readings over and over again.	1	2	3	4	5	6	7
47.	When a theory, interpretation, or conclusion is presented in class or in the readings, I try to decide if there is good supporting evidence.	1	2	3	4	5	6	7
48.	I work hard to do well in this class even if I don't like what we are doing.	1	2	3	4	5	6	7
49.	I make simple charts, diagrams, or tables to help me organize course material.	1	2	3	4	5	6	7
50.	When studying for this course, I often set aside time to discuss course material with a group of students from the class.	1	2	3	4	5	6	7
51.	I treat the course material as a starting point and try to develop my own ideas about it.	1	2	3	4	5	6	7
52.	I find it hard to stick to a study schedule.	1	2	3	4	5	6	7
53.	When I study for this class, I pull together information from different sources, such as lectures, readings and discussions.	1	2	3	4	5	6	7

54.	Before I study new course material thoroughly, I often skim it to see how it is organized.	1	2	3	4	5	6	7
55.	I ask myself questions to make sure I understand the material I have been studying in this class.	1	2	3	4	5	6	7
56.	I try to change the way I study in order to fit the course requirements and instructor's teaching style.	1	2	3	4	5	6	7
57.	I often find that I have been reading for this class but don't know what it was all about.	1	2	3	4	5	6	7
58.	I ask the instructor to clarify concepts I don't understand well.	1	2	3	4	5	6	7
59.	I memorize key words to remind me of important concepts in this class.	1	2	3	4	5	6	7
60.	When course work is difficult, I either give up or only study the easy parts.	1	2	3	4	5	6	7
61.	I try to think through a topic and decide what I am supposed to learn from it rather than just reading it over when studying for this course.	1	2	3	4	5	6	7
62.	I try to relate ideas in this subject to those in other courses whenever possible.	1	2	3	4	5	6	7
63.	When I study for this course, I go over my class notes and make an outline of important concepts.	1	2	3	4	5	6	7
64.	When reading for this class, I try to relate the material to what I already know.	1	2	3	4	5	6	7
65.	I have a regular place set aside for studying.	1	2	3	4	5	6	7
66.	I try to play around with ideas of my own and relate them to what I am learning in this course.	1	2	3	4	5	6	7
67.	When I study for this course, I write brief summaries of the main ideas from the readings and my class notes.	1	2	3	4	5	6	7
68.	When I can't understand the material in this course, I ask another student in this class for help.	1	2	3	4	5	6	7
69.	I try to understand the material in this class by making connections between the readings and the concepts from the lectures.	1	2	3	4	5	6	7
70.	I make sure that I keep up with the weekly readings and assignments for this course.	1	2	3	4	5	6	7
71.	Whenever I read or hear an assertion or conclusion in this class, I think about possible alternatives.	1	2	3	4	5	6	7
72.	I make lists of important terms for this course and memorize the lists.	1	2	3	4	5	6	7
73.	I attend this class regularly.	1	2	3	4	5	6	7

74.	Even when the course materials are dull and uninteresting, I manage to keep working until I finish.	1	2	3	4	5	6	7
75.	I try to identify students in this class whom I can ask for help if necessary.	1	2	3	4	5	6	7
76.	When studying for this course, I try to determine which concepts I don't understand well.	1	2	3	4	5	6	7
77.	I often find that I don't spend very much time on this course because of other activities.	1	2	3	4	5	6	7
78.	When I study for this class, I set goals for myself in order to direct my activities in each study period.	1	2	3	4	5	6	7
79.	If I get confused taking notes in class, I make sure I sort it out afterwards.	1	2	3	4	5	6	7
80.	I rarely find time to review my notes or readings before an exam.	1	2	3	4	5	6	7
81.	I try to apply ideas from course readings in other class activities such as lecture and discussion.	1	2	3	4	5	6	7

Appendix D

Examples of Each Goal Condition

See web links for generic examples of each of the conditions.

Control:

http://crippen.nevada.edu/chemistry/WE_Study/Example_Conditions/Muis_example_01.html

Mastery:

http://crippen.nevada.edu/chemistry/WE_Study/Example_Conditions/Muis_example_02.html

Performance-Approach:

http://crippen.nevada.edu/chemistry/WE_Study/Example_Conditions/Muis_example_03.html

Combined:

http://crippen.nevada.edu/chemistry/WE_Study/Example_Conditions/Muis_example_04.html

Appendix E

Prior Knowledge Questionnaire for Study 2

1. What is the name of Na_2O? {naming compounds}

disodium monoxide
sodium monoxide
sodium dioxide
sodium (I) oxide
* sodium oxide

2. Balance the following equation: {balancing equations}

$B_2O_3(s) + HF(l) \rightarrow BF_3(g) + H_2O(l)$

* $B_2O_3(s) + 6HF(l) \rightarrow 2BF_3(g) + 3H_2O(l)$
$B_2O_3(s) + HF(l) \rightarrow BF_3(g) + H_2O(l)$
$B_2O_3(s) + 2HF(l) \rightarrow 2BF_3(g) + H_2O(l)$
$B_2O_3(s) + 3HF(l) \rightarrow 2BF_3(g) + 3H_2O(l)$
$B_2O_3(s) + 6HF(l) \rightarrow 2BF_3(g) + 6H_2O(l)$

3. Sodium tripolyphosphate is used in detergents to make them effective in hard water. Calculate the oxidation number of phosphorus in $Na_5P_3O_{10}$. {ReDox}

+3
* +5
+10
+15
none of these

4. Calculate the enthalpy change for the reactions

$NO(g) + O(g) \rightarrow NO_2(g)$

from the following data: {Hess' law}

$NO(g) + O_3(g) \rightarrow NO_2(g) + O_2(g) \quad \Delta H = -198.9$ kJ
$O_3(g) \rightarrow 1.5O_2(g) \quad \Delta H = -142.3$ kJ
$O_2(g) \rightarrow 2O(g) \quad \Delta H = 495.0$ kJ

-551.6 kJ
* -304.1 kJ
190.9 kJ
153.8 kJ

438.4 kJ

5. Methane, $CH_4(g)$, reacts with steam to give synthesis gas, a mixture of carbon monoxide and hydrogen, which is used as starting material for the synthesis of a number of organic and inorganic compounds.

$CH_4(g) + H_2O(g) \rightarrow CO(g) + 3H_2(g)$

What mass of hydrogen is formed if 275 L of methane is converted to synthesis gas at STP? {gas stoichiometry}

12.3g
24.7 g
37.1 g
49.4 g
* 74.2 g

6. Bromine is the only nonmetal that is a liquid at room temperature. Consider the isotope bromine-81and select the combination which lists the correct atomic number, neutron number, and mass number, respectively. {properties of atoms}

Bromine-81

* 35, 46, 81
35, 81, 46
81, 46, 35
46, 81, 35
35, 81, 116

7. A sample of oxygen gas has its Kelvin temperature halved while the pressure of the gas remained constant. The initial volume of the gas is 400 mL. What is its final volume? {gas laws}

20 mL
133 mL
* 200 mL
400 mL
800 mL

8. Which of the following elements has the largest atomic radius? {periodicity}

Li
Ne
Rb
* Sr
Xe

9. Select the correct Lewis structure for NF_3. {VSEPR-geometry}

(unable to copy image)

* a
b
c
d
e

10. Select the correct electron configuration for Cu (Z = 29). {electrons in atoms-electronconfiguration}

$[Ar]4s^2 3d^9$
$[Ar]5s^2 4d^9$
$[Ar]4s^2 4p^6 3d^3$
$[Ar]4s^2 4d^9$
* $[Ar]4s^1 3d^{10}$