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The effects of feedback protocol on self-regulated learning in a web-based worked example learning environment

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ABSTRACT

The current research investigated the effects of differing feedback protocols in a Web-based worked example learning environment to determine if changes would occur over time in goal orientation, self-regulation, self-efficacy or achievement. Participants from an undergraduate chemistry course were assigned to either a norm-referenced or self-referenced feedback group to receive feedback in relation to their performance on a weekly quiz administered via the Web. Results revealed that participants did not significantly change their goal orientation type or magnitude as a result of the differing feedback protocols, even with the addition of learning environment perception as a potential mediating variable. However, participants made significant decreases along the mastery approach and performance approach goal orientation sub-scales, regardless of the type of feedback received. While this was not anticipated, the results are consistent with other recent research within this context. An unanticipated trend also emerged, as those from the norm-referenced feedback group with a class-task perception of the learning environment were less likely to use worked examples but also demonstrated the greatest gains in self-efficacy. These were unanticipated outcomes and contrary to prior research. Recommendations for future research within this context such as authenticating participants' perceptions of their assigned treatment condition, introducing additional feedback protocols such as a combined, choice, or control condition and building in a better gauge to track the time and context of changes within the constructs of interest are also discussed.

1. Introduction

The application of multimedia learning has made it possible to deliver continuous, timely, individualized and pedagogically relevant feedback to learners while maintaining an efficient use of limited cognitive resources. However, the effects of feedback as well as the optimal conditions that make best use of it represent a fairly new research direction. Investigations that aim to establish a framework for optimal feedback delivery systems within multimedia learning applications represent a practical undertaking. For example, it was recently established that accounting for learner preferences in regard to the type of feedback provided was not an empirically fruitful endeavor, and can even serve as a deterrent in some cases (Bower, 2005). Motivation theory is not sufficiently robust to offer an *a priori* mechanism for determining an optimal form of feedback based upon personal characteristics, nor does the theory predict well how the form of feedback might interact with achievement goal motivation. Winne, Muis, and Jamieson-Noel (2004) "urge researchers to further examine whether tasks, feedback, or both change students' goal orientation framework" (p. 39) and Linnenbrink (2005) states "a developmental perspective assessing personal goals and underlying dispositions and using objective measures of the goal context would allow one to more carefully trace the unique effects of these predictors to learning-related outcomes and the potential of a given classroom goal context to alter personal goal orientations over time" (p. 209). The debate in regard to the malleability of goal orientation over time and learning context has also seen a recent resurgence due to the work of Pintrich and course management and assessment systems now available via the Web. Electronic course management systems now make it possible to trace not only the perceptions of the learner, but the actions taken to master course content.

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A need exists for experimental investigations with feedback protocol, goal orientation, self-efficacy, self-regulation, and achievement in multimedia learning environments. While the effects of feedback on achievement and motivation have been mostly inconclusive, a majority of these studies provided the same type of feedback for all learners (Johnson, Maruyama, Johnson, Nelson, & Skon, 1981; Winne et al., 2004; Winne, Muis, & Jamieson-Noel, 2006). Furthermore, other research which did manipulate feedback protocol failed to include motivational variables (Bower, 2005) or implemented large scale environmental differences (Bong, 2004; Linnenbrink, 2005) making it difficult to attribute empirical findings to one single condition (i.e., an entirely different classroom and instructor as opposed to changes in feedback alone). In addition, the lack of a pre-test in one of these related studies (Linnenbrink, 2005) adds additional spurious possibilities to treatment effects.

A better understanding of the interaction between the form of feedback and motivation would have important practical implications. Conclusions could offer instructors, software companies, and instructional designers empirically sound advice for effectively building feedback protocols into multimedia learning programs. As such, this study sought to measure changes in goal orientation, self-regulation, self-efficacy, and achievement as a result of differing feedback protocol with learning environment perception as a potential mediating variable.

1.1. Theoretical framework

This research was framed within social cognitive theory (Bandura, 1997) which depicts the learner as a deliberating agent in the learning process who approaches academic tasks based on motivational dispositions. The results of a path analysis by Zimmerman and Bandura (1994) contributed more predictive power to this model only when a goal setting measure was introduced, thus substantiating a need for additional investigation with motivational constructs. Therefore, this theory assumes that a clear and well-defined goal or desired outcome is necessary in order for the learner to effectively monitor, compare and regulate learning activities, thus making goal orientation a paramount component of the theory. Additionally, self reports alone do not provide a comprehensive depiction of self-regulated learning (SRL) and should be used in conjunction with distinct data points obtained through other methods such as trace to best triangulate a more complete scenario of self-regulated learning (Winne & Hadwin, 1998).

The following section reviews the literature related to the relevant constructs of goal orientation, worked examples as a self-regulated learning strategy, self-efficacy, and the relationships among these variables and academic achievement.

1.2. Goal orientation

The categories of goal orientation utilized in the current study are derivative of a two by two matrix (Table 1) which outlines two dimensions, perceived task definition and valance (Elliot & McGregor, 2001). This theoretical construct has evolved from the work of Dweck (1986), who suggested that individuals possess either a learning (i.e., mastery) goal orientation where the goal of learning is to master the material, or a performance goal orientation where individuals strive to obtain favorable evaluation from others. Later research added valance to the theory, conceptualized by approach versus avoidance. Approach behaviors are those that strive to achieve successful judgments from others or themselves and are thought of as having a positive valance. Conversely, avoidance behaviors refer to intrinsic motivations that stem from the evasion of failure and appearing incompetent in front of others. Avoidance orientations are regarded as containing a negative valance. Therefore, the four categories are (a) mastery approach (where a person is driven to achieve for the sake of learning how to successfully complete a task), (b) mastery avoidance (where a person strives to avoid misunderstanding or making an error), (c) performance approach (marks the goals of achievement to outperform others) and (d) performance avoidance (individuals who are most likely motivated for the sake of avoiding embarrassment compared to others on the same task).

While a majority of research has demonstrated consistent empirical evidence of stronger relationships between a mastery approach goal orientation and intrinsic motivation, self-efficacy and deep processing cognitive strategies (Ames, 1992), its predictive power for self-regulated learning has been restricted to self-reported measures (Pintrich, 2000). The discussion of performance goal orientation as an antecedent of the same outcomes however, has received a mixture of results. While some research has focused on the maladaptive patterns that follow from a performance approach goal orientation (Dweck & Leggett, 1988), recent research has challenged this position when other factors such as context and motivation are considered. While VandeWalle, Brown, Cron, and Slocum (1999) found a positive relationship between performance goal orientation and sales commissions, Harackiewicz, Barron, Pintrich, Elliot, and Thrash (2002) have also noted positive relationships with task value, academic concept, effort and performance. Furthermore, Pintrich (2000) demonstrates some adaptive patterns for performance approach goals under a revised theory that allows for learners to progress through different goal orientations dependent upon the context and desired outcome. Elliot and Church (1997), Elliot and McGregor (2001) also identified performance approach goals as a significant predictor for graded performance with subjects high on performance approach goal orientation and low on mastery approach goal orientation receiving the highest grades. In fact, Harackiewicz et al. (2002) have gone so far as to claim that in a typical academic setting mastery approach goals will only predict interest and enjoyment of a course but performance goals will predict grades and subsequent grade point average.

Table 1
Goal orientation definitions (Elliot & McGregor, 2001).

Valence	Task definition	
	Absolute/intrapersonal (mastery)	Normative (performance)
Positive (approaching success)	Mastery approach goal	Performance approach goal
Negative (avoiding failure)	Mastery avoidance goal	Performance avoidance goal

1.3. Worked examples as a self-regulated learning strategy

Worked examples are sample problems which have already been solved and provide the learner with a model representation about how to think though complex items (Mwangi & Sweller, 1998). They are intentionally similar in content and structure to the quiz items under consideration for the current study. Worked examples are not scripted, but provide the learner with a knowledge base to understand concepts by demonstrating the necessary steps taken to arrive at a defined solution. They are an especially effective technique for increasing the problem solving skills of novice learners (Kalyuga, Chandler, Tuovinen, & Sweller, 2001), but can also assist in the same way with a more comprehensive audience of learners (Ward & Sweller, 1990). Worked examples also provide an efficient use of limited cognitive resources needed for schema acquisition preferable to mean-ends analysis problem solving methods (Sweller, 1988). Since worked examples are opened only when prompted by the user (learner), we consider this action a self-regulatory behavior.

The learning environment and other contextual factors such as the type of self-regulated strategies encouraged can serve as a mediating variable between goal orientation and achievement. The current project gives additional insight to the conclusions of Wolters, Yu, and Pintrich (1996) by focusing on the use of worked examples that encourage learners oriented towards performance goals to use more simplistic forms of self-regulation such as rehearsal. Interactions of self-regulated learning, self-efficacy, goal orientation and performance can very well depend on the type of self-regulated learning strategy employed. Since studying worked examples present a distinct advantage to learners with a lower level of knowledge, a performance goal orientation can be a positive predictor of worked example usage (Crippen, Biesinger, Muis, & Orgill, 2009). The work of Steele-Johnson, Beauregard, Hoover, and Schmidt (2000) supports this prediction in that performance oriented students would flourish in a worked example environment. If those with a performance approach orientation prefer simpler tasks (Steele-Johnson et al., 2000) it follows that those who adopt higher levels of performance approach goal orientations would benefit most from worked examples as a self-regulated learning strategy. Performance approach goal orientation then should lead to the increased use of self-regulation strategies.

1.4. Self-efficacy

Self-efficacy (Bandura, 1977, 1997), under the implication of social cognitive theory, is defined as "beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments" (p. 3). The influence of perceived self-efficacy as a significant predictor of behavior is supported in the literature (Kennett & Keefer, 2006). Bandura's review of research also confirms the predictive validity of self-efficacy while accounting for other variables such as locus of control and ability. Similar to goal orientation, individuals with higher self-efficacy typically view successful task completion as highly dependent upon effort and persistence and will often choose more challenging tasks due to their perceived benefits (Dweck & Leggett, 1988; VandeWalle et al., 1999). Individuals with a lower self-efficacy may view increased effort as an indicator of lower ability and be drawn to the simplest of tasks as a coping mechanism to avoid failure (Dweck, 1999).

Self-efficacy was included in the current study to provide an indication of student engagement with content via worked examples and as a precursor to achievement. Worked examples serve as an effective modeling strategy, whereby learners engage with content similar to their own ability level. The confidence gained from learning with models such as worked examples has been shown to increase self-efficacy (Schunk, 1996), and students making these gains in self-efficacy are more likely to persist with difficult tasks even when initial efforts are unsuccessful (Pajares, 2002). This additional perseverance is particularly essential for undergraduate science since learners often lose confidence in this subject as they progress through school (Pell & Jarvis, 2001). Prior research conducted within the Web-based quizzing system used for the current study has already established worked examples as a precursor of increased achievement and self-efficacy (Crippen & Earl, 2007). The current study aims to extend the scope of these investigations to test the impacts of its feedback protocol on similar outcomes such as self-efficacy.

1.5. The current investigation

The current study attempts to investigate the impact of feedback protocol on self-efficacy, use of worked examples, and achievement using a Web-based quizzing system for undergraduate chemistry. The research questions used to drive the study are the result of gaps identified in current scholarly literature from three primary studies. Bower (2005), tested the effects of feedback on self-efficacy and achievement with high school students in a mathematics learning environment but failed to include learner preferences such as goal orientation. Winne et al. (2006) looked for changes in goal orientation relative to feedback, but administered identical feedback to all learners, thus losing any potential impacts of differentiated feedback. Linnenbrink (2005), made a similar investigation into the effects of learning environment (mastery vs. performance) on goal orientation, self-efficacy, and performance, however the absence of a pre-test makes it impossible to trace these impacts at the subject level over time.

Only feedback protocol was manipulated in the current study, thus strengthening its potential links with goal orientation, self-efficacy, achievement, and use of worked examples. In a similar vein, Anderman and Midgley (1997) noted that students exposed to more normative evaluation procedures will adopt more performance based goal orientations. Still, their context was also quite broad (the transition from elementary to middle school) making it equally difficult to precisely determine how much of this was in fact a circumstance of the environment (such as feedback) and how much of the variance might be attributed to other factors such as age, school structure, time and course.

Based on these identified theoretical gaps and the recommendations of Linnenbrink (2005), the current study addressed the following research questions. A logic model of the research design is included as Fig. 1.

1 - Do distinctions in feedback protocol, perceptions of the learning environment and their alignment with one another interact to produce notable differences in self-efficacy and achievement (Table 2)?
2 - Do learners adopt different self-regulation strategy usage patterns when they are exposed to differing feedback protocols?
    a. If so, are these unique patterns dependent upon perceptions of the learning environment?

3 - Are changes in goal orientation over time mediated by differences in feedback protocol?

a. If so, do these change patterns differ based on perceptions of the learning environment and their alignment to the feedback protocol used (Table 2)?

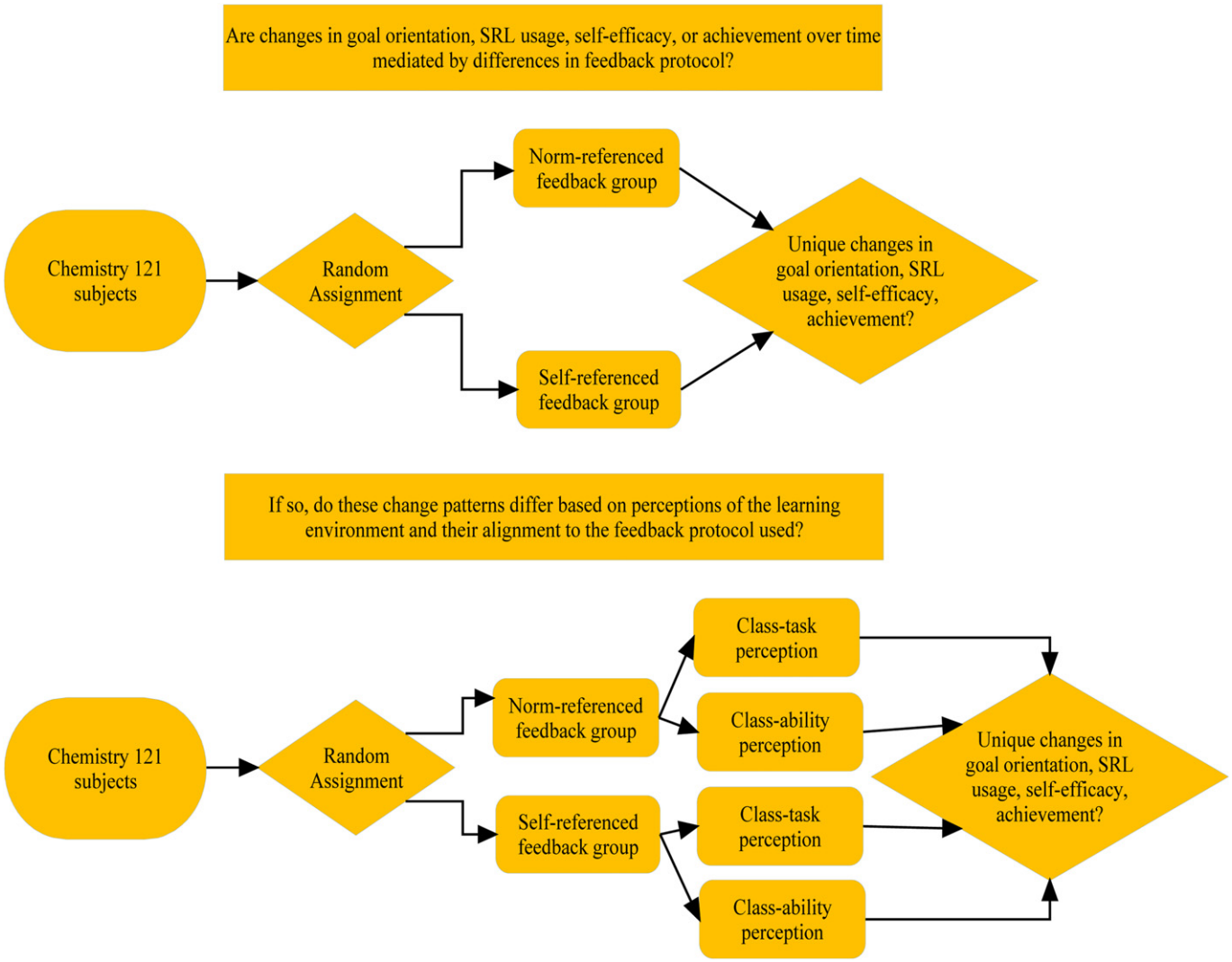


Fig. 1. Research design logic model.

Table 2
Design for learning environment perception and feedback protocol alignment.

Classroom goal perception	Assigned feedback protocol	
	Self-referenced	Norm-referenced
Class-task	Aligned	Not aligned
Class-ability	Not aligned	Aligned

2. Methods

The current project represents part of a large scale effort that has been active for several years using a Web-based interface to provide additional practice with well-structured chemistry problems through the use of worked examples embedded into weekly quiz items. The quizzing system is theoretically grounded within salient lines of research which have demonstrated support for the use of worked examples and coupled self-explanation prompts (Sweller, 1988). Indeed, these instructional strategies have been empirically demonstrated to effectively help students build well-structured problem solving skills. The system also explores the impacts of these pedagogical techniques

upon academic performance as well as latent variables such as motivation. Lack of adequate sample size has precluded past efforts to detect statistically significant changes in motivation, however initial trends have shown positive relationships with achievement, problem solving skills and self-efficacy (Crippen & Earl, 2004, 2007). In addition, students make extensive use of the worked examples as well as the self-explanation prompts. These efforts have been used to make helpful adaptations based on qualitative as well as quantitative data elements such as the pairing of worked examples and self-explanation prompts as opposed to offering them separately. As such, optional worked examples are made available in conjunction with weekly quiz items and delivered via a Web-based learning environment. Because worked examples were offered to participants as an option, usage was defined as an explicit self-regulated learning strategy.

The current research operated within three primary conditions that guided project design. First, feedback protocol was controlled while holding all other factors constant, allowing for a more concise interpretation of the results. Second, goal orientation was assumed to be a trait-like construct and was measured as such. Pre-post survey administrations were used to capture anticipated changes. Third, random assignments to unique feedback protocols were used to test predicted changes in goal orientation. Whereas Winne et al (2004) investigated changes in goal orientation over time, an identical feedback protocol was used for all participants. Conversely, Bower (2005) made controlled changes to feedback protocol and accounted for feedback preferences into his experimental design, however no indication of goal orientation was included. Thus, the current research generated a hybrid of these two studies while including other key mediating variables such as self-efficacy and worked example use.

2.1. Participants

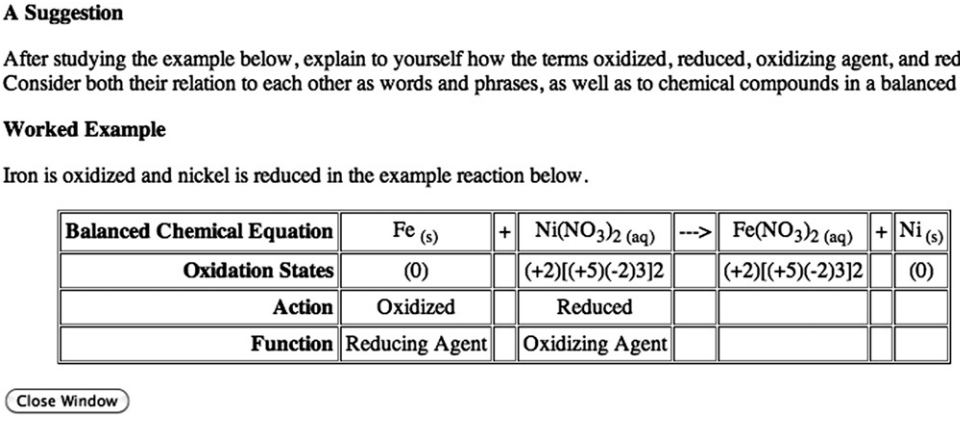
A sample of 184 undergraduate students from a large, urban southwestern university consented to the study. Participants were drawn from an introductory Chemistry course during the fall 2007 and spring 2008 semesters. All participants were exposed to an identical curriculum with the same instructor for each semester. The standing of the participants was: 46% freshman, 18% sophomores, 19% juniors, 7% seniors, 10% undefined, and one masters student. Participant majors included: 37% biology, 10% chemistry, 10% engineering, 6% kinesiology, and 15% undeclared. Other majors represented with one to three participants each included: architecture, education, history, nursing, nutrition, physics, and psychology.

2.2. Procedure

Participants met on a traditional semester calendar with weekly face-to-face class meetings and used the Web-based courseware system provided to the campus as an instructional supplement to communicate with other students or the instructor and to access the quizzing system, notes, homework assignments, extra practice problems, and solution sets. The course management system automatically presented each survey, including the informed consent option (IRB: 0505–1589) and was used to collect all survey data. The first author, as a representative of the research team, met with participants at the beginning of each semester to obtain consent and to disseminate instructions on how to complete the surveys.

Participants accessed the quizzing system from within the courseware environment. Though distinct products, the user interface of the quizzing system was built to complement the courseware interface so as to blur the distinction between the two and create a more homogeneous learning environment. These worked examples were embedded into a subset of (on-line) quiz items as three buttons labeled “Example 1”, “Example 2”, and “Example 3”. Example buttons were made available on well-structured quiz items, however the worked example was not revealed unless selected by the learner (i.e., clicking on one of the buttons). Hence, the choice to use a worked example resided within each learner’s volition and was therefore viewed as a self-regulated learning strategy.

Once a worked example button was clicked, a new window opened containing a self-explanation prompt (called a suggestion) and a worked example similar in format and content to the current quiz item (Fig. 2). Self-explanation is a form of self-talk where a learner engages in an iterative personal dialog while engaged in problem solving (Atkinson, Derry, Renkl, & Wortham, 2000). The design of the self-explanation prompts was based on the guidelines provided by Renkl and Atkinson (2003). The designers of the system have worked since the inception of the project to ensure that the worked examples and self-explanation prompts are aligned with the course content and that the language used parallels that of the lectures and textbook.



A Suggestion

After studying the example below, explain to yourself how the terms oxidized, reduced, oxidizing agent, and reducing agent are used. Consider both their relation to each other as words and phrases, as well as to chemical compounds in a balanced chemical equation.

Worked Example

Iron is oxidized and nickel is reduced in the example reaction below.

Balanced Chemical Equation	$Fe_{(s)}$	+	$Ni(NO_3)_{2\,(aq)}$	--->	$Fe(NO_3)_{2\,(aq)}$	+	$Ni_{(s)}$
Oxidation States	(0)		(+2)[(+5)(-2)3]2		(+2)[(+5)(-2)3]2		(0)
Action	Oxidized		Reduced				
Function	Reducing Agent		Oxidizing Agent				

Close Window

Fig. 2. A representative worked example/self-explanation example (K J Crippen & Earl, 2004).

Each quiz contained five multiple-choice items. Based upon curriculum needs, the course instructor (not a member of the research team) selected items by content and difficulty level. Item stems and possible responses were randomly generated by the quizzing system, each with a correct answer and alternative responses. If an item required well-structured problem solving skills (i.e. multiple steps with one clear solution), then a collection of three worked examples accompanied the item. Since item stems and responses were randomly selected, the likelihood of two participants receiving identical questions or responses was small. Worked examples were related to the type of item and not to the stem, so participants with different question stems were still exposed to identical worked examples.

Participants were given access to quizzes for one week and could modify their responses at any time. At the close of each week, the quizzes were graded (number correct). For participants failing to reach the desired mastery level of 80% a quiz retake option was available for an additional week. Items given on the quiz retake contained different item stems but remained parallel in form and content to those on the original quiz and the worked examples were identical.

Data collection consisted of three self-report surveys, a tally of worked example usage, and overall course grades. Participants completed two pre-post surveys, once at the beginning of the semester and again at the close of the semester. The instruments were identical for each administration in order to accurately measure changes in self-efficacy and goal orientation. Additionally, the Patterns of Adaptive Learning Survey (PALS) (Midgley, Maehr, Hicks, Urdan, & Roeser, 1995) was administered three weeks into each semester to gauge perceptions of the learning environment. In addition to these three measures, a cumulative total representing the number of times each participant prompted the system to launch a worked example was tracked. Final course grades were also obtained to indicate achievement for purposes of analysis. A complete discussion of the data elements to be included follows in the measures section.

Participants were randomly assigned to one of two feedback protocol groups that served as the treatment to be tested with each of the three research questions. The protocols used the same design as Bower (2005) with feedback given to all participants continuously and updated after each of the weekly quizzes. The feedback was confined in form to the contents of a single bar graph. The first group, referred to as the norm-referenced feedback group, received feedback in relation to all other learners in the course section (Fig. 3). In addition to their raw score, participants from the norm-referenced feedback group received their cumulative quiz performance in comparison to all learners. The second, referred to as the self-referenced feedback group, received feedback on cumulative quiz performance in comparison only to their own prior attempts (Fig. 4). The format (user interface) for presenting the feedback was similar for both groups, with the only distinction between the two feedback protocols being the data used to calculate each comparison and the legend (i.e. the second bar from each graph). Specifically, the system indicated whether the feedback represented performance compared to other learners or themselves, so learners were made aware of which feedback group they were in.

2.3. Measures

2.3.1. Goal orientation

The Achievement Goals Questionnaire (AGQ) was used to measure goal orientation. Andrew Elliot, Marcy Church and Holly McGregor developed the instrument over the course of several years and numerous experiments (Elliot, 1999; Elliot & Church, 1997; Elliot & McGregor, 2001) to assess individual goal orientation factors on four different (although not mutually exclusive) categories. The instrument has been shown to be reliable and valid (Elliot, 1999; Elliot & Church, 1997; Elliot & McGregor, 2001). The AGQ (in its most current form) is a 12-item Likert style survey (*1 = not at all true of me, 4 = somewhat true of me, 7 = very true of me*), with three items grouped for each of four achievement goal categories. The target population for the instrument could potentially be all learners from elementary school through adult, but current practices typically focus on undergraduate students. The premise of the instrument is that relationships between individual goal orientations and achievement can be used to make informed pedagogical decisions and therefore shape instructional techniques to best assist students.

2.3.2. Perception of the learning environment

Perception of the learning environment was gauged with two scales adopted from the *Patterns of Adaptive Learning Survey (PALS)* (Midgley et al., 1995). The two scales measured learner perceptions of a *class-task goal structure* (mastery orientation) with six items and of a *class-ability goal structure* (performance orientation) with five items. Prior research has shown the two sub-scales to be reliable ($\alpha = .81$ for

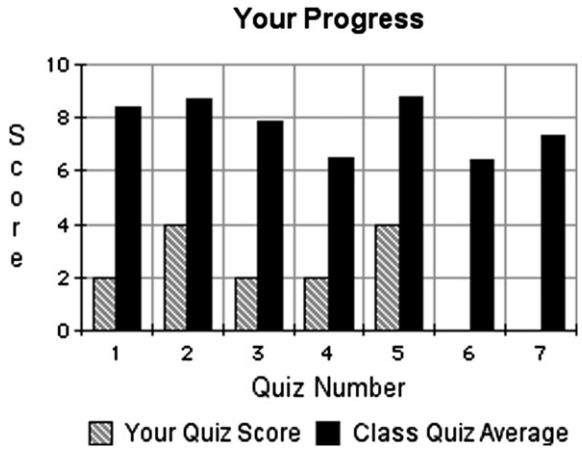


Fig. 3. Norm-referenced feedback protocol.

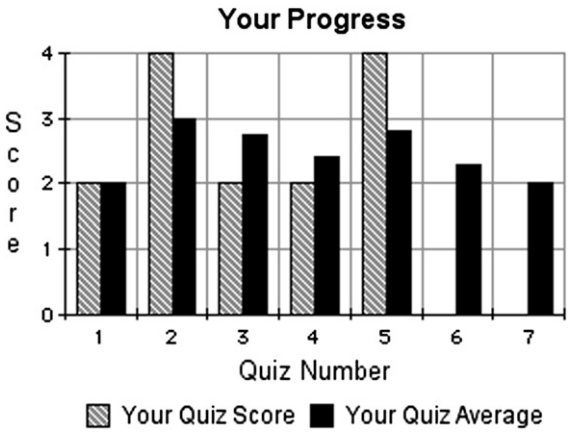


Fig. 4. Self-referenced feedback protocol.

class-task and $\alpha = .80$ for class-ability) and meet the assumptions of multicollinearity (Roeser, Midgley, & Urdan, 1996). Items for both scales were measured on a 7-point Likert scale (*1 = not at all true in this class, 4 = somewhat true in this class, 7 = very true in this class*).

In an effort to assign participants a single numeric value to represent their classroom ability goal perception, a difference score between the two sub-scales of the PALS instrument (class-task and class-ability) was tabulated (VandeWalle & Cummings, 1997). The difference score was calculated by subtracting the total score for the class-ability subscale (5 items, minimum score = 5, maximum score = 35) from the total score for the class-task subscale (6 items, minimum score = 6, maximum score = 42). This resulted in a synthetic variable, which will be referred to as "perception" with a potential range of −29 to 37. A score closer to 37 indicates a greater propensity to adopt a class-task (i.e., mastery) perception of the classroom goal structures present. A score closer to −29 indicates a greater propensity to adopt a class-ability (i.e., performance) perception of the classroom goal structures present. A median split on the difference score was used to assign participants to either a class-task or class-ability perception group.

2.3.3. Self-efficacy

In addition to the AGQ, participants completed a self-efficacy measure (Crippen & Earl, 2004, 2007) which pertained specifically to the Chemistry content of the course (herein referred to as Self Efficacy Chemistry or SEC) given pre and post instruction. Items were measured on a 6-point Likert scale (1 = *Not Confident* to 6 = *Totally Confident*) and were focused within the context of the course under examination to provide maximum utility (Bandura, 1997; Pintrich, 2000).

2.3.4. Worked example usage

Worked example usage is a self-regulated learning strategy measure and represented the cumulative total number of times that each participant elected to view a worked example. Participants accessed the worked examples through the Web and a record of use was compiled on the server.

2.3.5. Achievement

Final course grades were reported as the total number of raw points earned by each participant. This total represented a cumulative aggregate of all quizzes, exams, graded assignments, and lab-work. Although eventually converted to a letter grade by the instructor, the number of total points earned was used to sustain the highest degree of accuracy and statistical variance. It should be noted that this value did not account for the number of quiz re-takes, although participants who improved their quiz scores did increase their total points earned.

3. Results

Data collection over the fall 2007 and spring 2008 semesters yielded a sample of 184 participants who consented to the study and completed all required surveys. Missing items were replaced with mean values for participants failing to complete fewer than four items on the AGQ (12 items total) as well as the PALS (11 items total). Mean values were also entered for participants with fewer than six incomplete items from the SEC (34 items total). Overall, 37 participants had one or more missing items but remained under the threshold of four or six missing items, respectively. Those with a higher occurrence of missing items were removed from the sample ($n = 84$). A visual inspection of each case indicated no obvious anomalies. Since participants were randomly assigned to a feedback group at the onset of each semester, the groups were unequal with $n = 88$ in the self-referenced group and $n = 96$ in the norm-referenced group. In addition, since a median split was used to assign participants to a class-task or class-ability learning environment perception group, 10 participants attaining a difference score equal to the group median (27.0) on the PALS were removed from all hypotheses involving the mediating variable. Of the remaining 174 participants assigned to either the class-task or class-ability perception group, 90 were assigned to the class-ability group while 84 were assigned to the class-task group. See Table 3 for participant group assignment counts.

Data were screened for normality, homogeneity, reliability, as well as the potential presence of univariate or multivariate outliers. Means, standard deviations, skewness and kurtosis values from each of the dependent measures as well as the PALS (mediating variable) are presented in Table 4. All item totals were well within acceptable normality parameters of +/− 3.0 for skewness and +/− 8.0 for kurtosis (Kline, 1998) with skewness values ranging from −1.96 to 2.47 and kurtosis values ranging from −.72 to 6.92. Box's *M* tests (multivariate) and Levene's tests (univariate) of homogeneity were not significant, indicating that the error variance from each of the dependent variables

Table 3
Subject group assignments.

		Feedback group		Total
		Self-referenced	Norm-referenced	
Learning environment perception	Class-ability	43	47	90
	Class-task	39	45	84
	Not assigned	6	4	10
Total	88	96	184	

was equal across groups. When the second grouping was assigned based on the mediating variable (learning environment perception), the null hypothesis for homogeneity of variance was rejected for several of the dependent variables including the combined (multivariate) goal orientation variable (pre-test), mastery approach (pre-test), performance approach (post-test), performance avoidance (pre-test and post-test), and self-regulation. Since this indicates unequal error variances across groups on these dependent measures, interpretation of the hypotheses in regard to the mediating variable will be reported cautiously. This is most likely due to a significantly smaller sample size when participants were split into a 2 × 2 factorial design due to the introduction of the mediating variable.

Reliability estimates were also calculated using Cronbach's Alpha test for each of the dependent item inventories. With the exception of the (overall) PALS instrument ($\alpha = .63$), all other measures were within acceptable ($\alpha > .70$) parameters (Shultz & Whitney, 2005). Hence, data analysis and interpretation in regard to the effects of learning environment perceptions are made with additional discretion. See Table 5 for Cronbach's Alpha reliability estimates for each of the measures used in the study.

Scores from each of the dependent measures of interest were also converted to *z* scores to identify and remove univariate and multivariate outliers using standard accepted statistical practices (Tabachnick & Fidell, 2007). Prior to analysis, the two feedback groups were also compared on each of the pre-tests to ensure that no significant differences in goal orientation or self-efficacy existed prior to treatment. An independent samples *t*-test confirmed that the two groups were homogeneous on all five pre-test scores prior to treatment with values ranging from $p = .086$ to $p = .958$ (two-tailed). An additional series of comparisons was also conducted on each of the dependent measures of interest to ensure that no significant differences were found between participants from each semester (spring and fall). Both groups were statistically equivalent on goal orientation (pre-post), self-efficacy (pre-post), self-regulatory strategy usage, and achievement with values ranging between $p = .082$ and $p = .855$. One noted significant difference between participants from the fall and spring semesters was class-task learning environment perception $F_{(2,182)} = .617$, $p = .002$. However, since participants were grouped on this variable and not on semester, this difference was disregarded.

3.1. Research question one: changes in self-efficacy and achievement

Tests of the interaction for self-efficacy approached statistical significance with a small effect size, $F_{(2,\ 178)} = 2.372$, $p = 0.096$, $\eta^2 = .026$. Follow up tests with the main effects were also inconclusive for feedback group, $F_{(1,\ 178)} = 2.307$, $p = .131$ as well as learning environment perception group, $F_{(2,\ 178)} = 2.018$, $p = .136$. Power estimates for each of the ANOVA tests ranged from .327 to .413. In other words, participants did not demonstrate significant changes in self-efficacy over time as a result of introducing the mediating variable. See Table 6 self-efficacy descriptive statistics along the 2 × 2 factorial.

A one-way ANOVA was conducted to probe potential differences in achievement using the same 2 × 2 factorial (feedback group by learning environment perception group). A statistically meaningful interaction was not found for achievement, $F_{(2,178)} = 2.073$, $p = .129$. However, follow up tests did reveal a significant main effect for achievement over the learning environment perception group variable, $F_{(2,178)} = 4.071$, $p = .019$, $\eta^2 = .044$, with a small effect size, indicating that participants who demonstrated a class-task learning environment perception performed significantly better as indicated by final (semester) grades. A second follow-up test by feedback group was statistically null, $F_{(1,178)} = .326$, $p = .569$. See Table 7 for descriptive statistics on course achievement along the same 2 × 2 factorial.

Table 4
Descriptive statistics for dependent measures ($N = 184$).

	Min.	Max.	Mean	Std. deviation	Skewness	Kurtosis
Self-efficacy item total – pre-test	34.00	204.00	120.30	33.89	−.396	−.399
Self-efficacy item total – post-test	64.00	204.00	165.64	27.07	−1.201	2.036
Mastery approach item total – pre-test	4.00	21.00	18.88	2.77	−1.963	5.270
Mastery approach item total – post-test	3.00	21.00	18.11	3.33	−1.478	2.515
Performance approach item total – pre-test	3.00	21.00	15.37	4.92	−.622	−.578
Performance approach item total – post-test	3.00	21.00	14.14	5.19	−.495	−.597
Mastery avoid item total – pre-test	3.00	21.00	12.25	4.84	.012	−.723
Mastery avoidance item total – post-test	3.00	21.00	12.71	4.72	−.199	−.639
Performance avoid item – pre-test	3.00	21.00	16.20	4.10	−.924	.712
Performance avoidance item total – post-test	3.00	21.00	15.75	4.25	−.717	.086
PALS item total – class-task	12.00	42.00	33.89	5.52	−.790	.971
PALS item total – class-ability	5.00	35.00	8.57	5.44	2.468	6.920
Self-regulation (cumulative number of clicks)	0	324	89.68	65.68	.991	.751
Overall course grade	319.25	736.70	602.61	80.69	−.652	.153

Table 5
Reliability estimates using Cronbach's alpha values.

Variable	Cronbach's alpha
PALS (overall)	.63
PALS (class-task)	.73
PALS (class-ability)	.83
AGQ (pre-test)	.80
AGQ (post-test)	.81
Mastery approach (pre-test)	.82
Mastery approach (post-test)	.86
Mastery avoid (pre-test)	.83
Mastery avoid (post-test)	.81
Performance approach (pre-test)	.89
Performance approach (post-test)	.92
Performance avoid (pre-test)	.76
Performance avoid (post-test)	.81
SEC (pre-test)	.97
SEC (post-test)	.97

3.2. Research question two: changes in self-regulation strategy patterns

Results of the *t*-test indicated no significant difference in the number of worked example views between each of the feedback groups, $t_{(2,\ 182)} = .585$, $p = .559$. A similar (ANOVA) investigation with the introduction of the mediating variable also indicated no significant interaction, $F_{(2,\ 172)} = .608$, $p = .545$. Main effects for feedback group and learning environment perception group were also inconclusive, $F_{(2,\ 172)} = .056$, $p = .814$, and $F_{(2,\ 172)} = 1.350$, $p = .262$, respectively. See Table 8 for self-regulatory cumulative statistics by feedback group and learning environment perception. One interesting trend that emerged was a low frequency of worked example usage from participants in the norm-referenced feedback group with a class-task perception of the learning environment. However, these same individuals also demonstrated the greatest gains in self-efficacy. The authors did not anticipate this outcome.

While statistical significance was not obtained, propensity to use worked examples was much more diverse across participants from the class-task learning perception group with those from the self-referenced group demonstrating a higher average number of worked example "hits" than those from the norm-referenced group ($M_{NORM} = 72.96$ vs. $M_{SELF} = 89.72$). Therefore, if encouraging learners to use worked examples is a goal of instruction, assigning those with a class-task perception of their learning environment to a self-referenced feedback situation might be worthy of further investigation. Conversely, participants with a class-ability learning environment perception demonstrated homogeneity across the self-regulation construct ($M_{NORM} = 98.96$ vs. $M_{SELF} = 93.84$).

3.3. Research question three: changes in goal orientation

Results from the doubly multivariate analysis indicated no significant interaction between feedback group and time, $F_{(4,\ 176)} = .253$, $p = .907$, $\eta^2 = .006$ indicating that participant's goal orientation type did not change over time as a result of their feedback protocol. Since the interaction was not significant, inspections of the main effects were completed. Results of the main effects tests revealed no statistically detectable effect for the between-subjects factor (feedback group). However, two significant main effects did exist for the within-subjects factor (time). Specifically, significant changes were noted from pre to post-test on the mastery approach subscale, $F_{(1,\ 179)} = 16.13$, $p < .001$, $\eta^2 = .083$ as well as the performance approach subscale, $F_{(1,\ 179)} = 16.40$, $p < .001$, $\eta^2 = .084$, indicating a small effect size in both cases. In other words, participants demonstrated significant decreases over time on both sub-scales. See Table 9 for descriptive statistics of goal orientation indices by feedback group.

The second part of research question three introduced the mediating variable of learning environment perception. Results from the second doubly multivariate analysis indicated no significant interaction between feedback group, learning environment perception, and time, $F_{(8,\ 346)} = .744$, $p = .653$, $\eta^2 = .017$ indicating that participant's goal orientation type did not change over time as a result of their feedback protocol, even with the introduction of the mediating variable. Since the interaction was not significant, additional inspections of

Table 6
Self-efficacy descriptive statistics along the 2 × 2 factorial (feedback by perception).

Feedback group	Learning environment perception group	Self-efficacy	Mean	Std. error
Self-referenced	Class-ability	Pre	117.20	5.120
		Post	164.09	3.955
		Gain	46.89	
	Class-task	Pre	132.18	5.376
		Post	175.94	4.153
		Gain	43.76	
Norm-referenced	Class-ability	Pre	115.93	4.897
		Post	155.91	3.783
		Gain	39.98	
	Class-task	Pre	114.94	5.005
		Post	170.63	3.866
		Gain	55.69	

Table 7
Descriptive statistics on course achievement along the 2 × 2 factorial.

Feedback Group	Learning environment perception	Mean	Std. deviation	N
Self-referenced	Class-ability	598.35	82.99	43
	Class-task	635.56	67.12	39
	Not assigned	555.61	79.56	6
	Total	611.93	78.85	88
Norm-referenced	Class-ability	577.29	88.01	47
	Class-task	607.82	73.88	45
	Not assigned	636.41	59.13	4
	Total	594.06	81.82	96
Total	Class-ability	587.35	85.82	90
	Class-task	620.7	71.76	84
	Not assigned	587.93	80.14	10
	Total	602.61	80.69	184

the main effects were conducted. Univariate follow up tests were inconclusive, with no significant interaction from the combined between-subjects factors (feedback group × learning environment perception group) and no main effect for either between-subjects factor considered in isolation. Interaction effects for the within-subjects factor (time) by learning environment perception group were also investigated, revealing no statistically detectable changes in goal orientation.

4. Discussion

The current investigation attempted to isolate feedback from weekly quizzes administered via the Web to undergraduate chemistry students to determine if these changes would manifest change in goal orientation, self-efficacy, self-regulatory strategy usage, or performance. The results obtained did not support predictions that learners would adopt a goal orientation preference aligned to their feedback group and demonstrates some practical limitations of current SRL theory. However, marginal means did indicate that learners decreased their mastery approach and performance approach goal orientations. This is consistent with previous findings (Fryer & Elliot, 2007), especially when considered with feedback as a treatment (Senko & Harackiewicz, 2005).

Results from the current investigation confirmed that changes in goal orientation, self-regulation, self-efficacy, and achievement as a result of differing feedback protocol were not statistically detectable, even with the addition of learning environment perception as a potential mediating variable. However, all participants (regardless of their feedback group assignment) demonstrated significant decreases along both the mastery approach and performance approach sub-scales. In general, these mean-level group changes in goal orientation over the course of the semester are consistent with recent research conducted within similar contexts. Specifically, Fryer and Elliot (2007) found through a series of three experiments that participants did demonstrate significant group mean-level decreases in mastery approach and no statistically detectable changes in mastery avoidance orientation magnitude. However, performance approach goal orientation endorsements did not change significantly and performance avoidance increased significantly over time. The researchers also conducted person-level analyses to confirm these findings and found that a majority of participants were likely to decrease their mastery approach orientations and increase their performance avoid orientations. These additional analyses also confirmed that an equal number of participants were likely to increase or decrease their levels of mastery avoidance or performance approach orientations. However, as Fryer and Elliot (2007) acknowledge, this study was aimed to provide a "comprehensive portrait of achievement goal stability and change" (p.712), leaving more questions than answers in regard to when and under what circumstances learners will adopt differing goal orientations. The authors site self-regulation as a theoretically sound construct that should lead to changes in goal orientation depending upon the context and treatment under investigation. However, the lack of statistically detectable changes in goal orientation suggests some issues with current applications of self-regulation theory.

Another unanticipated trend also emerged, as those from the norm-referenced feedback group with a class-task perception of the learning environment were less likely to use worked examples but also demonstrated the greatest gains in self-efficacy. These were unanticipated outcomes, the second of which was contrary to our prediction. As predicted, participants from the self-referenced feedback, class-ability perception group as well as the norm-referenced feedback, class-task perception group did not demonstrate unique patterns in self-regulatory behaviors, however, participants from the remaining two groups (norm-referenced feedback, class-ability perception group and the self-referenced feedback, class-task perception group) also demonstrated no significant changes in self-regulatory behaviors contrary to the prediction made. Similar investigations along the 2 × 2 factorial revealed no significant differences in self-efficacy or achievement.

Table 8
Self-regulatory statistics by feedback group and learning environment perception.

		Feedback group		
		Self-referenced	Norm-referenced	Marginal means (perception)
Learning environment perception	Class-task	$M = 89.72$ SD = 53.46	$M = 72.96$ SD = 52.25	$M = 80.74$ SD = 53.17
	Class-ability	$M = 93.84$ SD = 63.92	$M = 98.96$ SD = 84.37	$M = 96.51$ SD = 74.93
	Marginal means (feedback)	$M = 92.65$ SD = 59.69	$M = 86.97$ SD = 70.93	

Table 9
Descriptive statistics of goal orientation indicies by feedback group.

AGQ subscale	Feedback group	Mean	Std. deviation	N
Mastery approach- pre-test	Self-referenced	19.10	2.44	87
	Norm-referenced	18.91	2.40	94
	Total	19.01	2.42	181
Mastery approach - post-test	Self-referenced	18.35	2.79	87
	Norm-referenced	17.00	3.47	94
	Total	18.17	3.16	181
Mastery avoidance - pre-test	Self-referenced	12.29	4.86	87
	Norm-referenced	12.32	4.67	94
	Total	12.31	4.75	181
Mastery avoidance - post-test	Self-referenced	12.82	4.77	87
	Norm-referenced	12.73	4.56	94
	Total	12.78	4.65	181
Performance approach- pre-test	Self-referenced	15.03	4.85	87
	Norm-referenced	15.67	4.98	94
	Total	15.36	4.91	181
Performance approach - post-test	Self-referenced	14.12	4.83	87
	Norm-referenced	14.31	5.36	94
	Total	14.22	5.10	181
Performance avoid - pre-test	Self-referenced	16.21	4.15	87
	Norm-referenced	16.43	3.82	94
	Total	16.33	3.98	181
Performance avoidance - post-test	Self-referenced	15.66	4.19	87
	Norm-referenced	16.05	4.12	94
	Total	15.86	4.15	181

The unanticipated trend whereby subjects from the norm-referenced feedback group with a class-task (i.e. mastery) perception of the learning environment were less likely to use worked examples could be explained by some oversights within the system. Specifically, the differences between the two feedback protocols (i.e. graphs) were so discrete that any potential impacts may have been irrelevant. Without validating subjects' awareness of their feedback received (such as through a survey question), it cannot be safely assumed that these differenced in self-regulatory behaviors and self-efficacy gains were the result of the treatment administered or a sampling error. Research does support the notion that those with a class-task perception of the learning environment would be prime candidates to significant increases in self-efficacy simply because they would be more inclined to perceive a direct relationship between effort and achievement.

Differences in self-regulatory behavior patterns also did not emerge as expected, with no statistically significant differences in the number of cumulative "clicks" by each learner to launch a worked example. While those from the class-ability, norm-referenced group and the class-task, self-referenced group were predicted to demonstrate the highest and lowest usage frequencies (respectively), only the first prediction was upheld and was not found to be statistically significant. Allowing for the lack of statistical significance, an interesting and unanticipated pattern was identified as participants from the class-task, norm-referenced group used worked examples far less than the remaining three groups. As predicted, participants from the class-ability, self-referenced group did not show self-regulation differences.

Investigations into achievement and self-efficacy were also inconclusive. Participants' grades from the course did not differ as a result of their feedback group assignment. Although no statistically detectable difference was evident, participants from the class-task, norm-referenced group demonstrated greater increases in self efficacy ($M_{\text{norm-referenced/class-task}} = 55.69$) compared to their counterparts from the remaining three groups ($M_{\text{self-referenced/class-ability}} = 46.89$, $M_{\text{self-referenced/class-task}} = 43.76$, $M_{\text{norm-referenced/class-ability}} = 39.98$). This was contrary to the predictions made and indeed an intriguing result. While this was labeled a "misaligned" condition, the results indicate that the effects of learning environment perceptions serve as a better predictor for achievement so it follows that perceptions would lead to greater changes in self-efficacy.

While more recent research has advocated for goal orientation as both a stable as well as a volatile construct (Fryer & Elliot, 2007), it is unclear as to the exact timing, treatment, and conditions that will create said changes in goal orientation. In addition, the current study investigated changes in performance as a function of feedback based on the premise that changes in feedback were based solely on random assignment to one of two unique conditions. However, as Senko and Harackiewicz (2005) demonstrated, learners will exhibit different perceptions of feedback based on their performance. In other words, within each feedback protocol exists another potential confounding variable; performance. Regardless of their assigned feedback protocol, participants most likely will change their goal orientation, self-efficacy, and self-regulation as a result of their current progress within the course. The addition of performance as a potential mediating variable is worthy of further investigation along this line of research.

Also, since it remains unclear as to the timing of when these changes might occur, the employment of multiple measurements of goal orientation over the course of the semester or a more accurate identification of events that may spark shifts within this variable is warranted. A better prediction as to the events that might be associated with potential shifts in goal orientation or self-efficacy would be a welcome addition to the current research as a more efficient and targeted administration of multiple goal orientation measures.

The current project has successfully closed several previously existing theoretical gaps in the literature regarding self-regulatory behavior patterns and motivational constructs within the realm of an online learning environment. First, learners remained anchored to their existing goal orientation and are not easily influenced to change these previously established patterns over the course of a typical semester. Second, feedback protocol might be best left to the learner through choice in how they are informed of their academic progress. What is now known is that perceptions of the learning environment and random manipulation of a learner's feedback protocol need not be continued, opening the door for future research within this arena to further examine other patterns that have surfaced.

4.1. Impact on learning theory

While the overall results may seem inconclusive, there are several lessons that can be learned from this and implications that could guide both instructors working in a technology rich environment as well as researchers interested in this line of work. For instructors, using learning environment perception as a predictor for success in a norm-referenced or self-referenced feedback group will most likely not pay academic dividends. It might be that a "combined" condition is well warranted, where students could view their progress in comparison to both their own past performance as well as that of their peers, especially if goal orientation is malleable over time and/or context. Offering choice may also be a better venture, allowing learners to self select a feedback protocol at the onset of the semester or letting them "toggle" between feedback protocols as they so choose. Thus, as learners decide (through self-regulation) to adopt a different goal orientation for reasons such as context, task, instructor, or otherwise, another option for receiving feedback would exist to support the newly adopted goal preference.

4.1.1. Limitations

Both statistical as well as theoretical factors contributed to the limitations from the current study. Results of the PALS survey included an overall low reliability measure. Therefore, even if significant differences were found in any of the outcome variables of interest as a result of the additional group division along this measure, interpretation of the results would have been cautious at best. Furthermore, a difference score was calculated across the two sub-scales (class-task and class-ability) to assign a single numeric value to each participant across both dimensions. Because of this somewhat arbitrary median split, some participants were artificially assigned to different groups. Assigning participants to three groups (one low, one medium, and one high) did not heed any major differences in the results.

Although reliability and validity of the AGQ has been established through prior research, placing participants' perceptions and goal orientation on a scale of one to seven does not provide much variance, making it difficult to attain statistical significance. The number of times a worked example was launched also has some potential weaknesses in that it is impossible to know exactly the intent of the learner. Since each worked example is combined with a self-explanation prompt, it cannot be deduced in the current study if each participant was impartial to one or the other. In fact, just because a worked example is opened does not mean that it was even read. In addition, repeatedly launching the same example yields the same number for this variable compared to someone who opens a unique worked example each time creating additional issues in regard to what a "click" represents.

As mentioned above, since the progress charts with a unique feedback protocol were on each participant's "home page" for the quizzing system, it cannot be assumed that they were reading them each time the page was opened. It was necessary to open this page in order to access any of the quizzes, creating a lot of traffic to this site, much of which could have been merely a pass through to get to another component within the quizzing system. It may have also been the case that participants used the worked examples more frequently at certain times of the academic term or depending upon the content of the quiz. Although this information could be obtained from server logs and the course syllabi, it was well beyond the scope of this study. In addition, the difference between the two feedback protocols was so discrete it is our belief that many of the participants were not aware of which group they were assigned to. Without an explicit question to ask this, it cannot be assumed that participants were aware their assigned treatment condition.

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