Mastery-approach goals and knowledge transfer: An investigation into the effects of task structure and framing instructions

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A B S T R A C T

Although prior work has shown that mastery-approach achievement goals are related to positive learning behaviors (e.g., more interest, perseverance, and self-regulation), less is known about how these goals interact with instruction to influence knowledge transfer. To address these issues we conducted a laboratory experiment investigating how two aspects of the instructional environment, the task structure (teLL-and-practice direct instruction vs. minimally-guided open-ended invention activities) and the task framing (mastery vs. performance), affected students’ task-based mastery goal adoption and transfer when learning statistics. The results showed that structure was more effective than framing in manipulating students’ mastery-goal adoption. In addition, students’ existing mastery-approach orientations for mathematics strongly predicted knowledge transfer for all of the instructional conditions except for students given invention activities with a performance framing. For these students, the relationship between mastery-approach orientation and transfer was not observed, indicating that this condition makes transfer more likely for those lower in mastery-approach orientation. The results are discussed in terms of the implications for theories of achievement goal motivation, knowledge transfer, and instruction.

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1. Introduction

A common goal of the cognitive and educational sciences is to understand how people learn new concepts and transfer them from one task or situation to another (Bransford & Schwartz, 1999; Lobato, 2006; National Research Council, 2000). Much research in cognitive psychology has focused on identifying the underlying cognitive processes and knowledge representations that either facilitate or inhibit knowledge transfer (for overviews see Determan, 1993; Gick & Holyoak, 1987; Nokes, 2009). Although some of this work has examined the role of individual variation in these processes (e.g., effects of expertise), the majority has ignored the effects of individual differences on transfer, especially with respect to motivation. In contrast, much work in the educational sciences has focused on the relationship between individual differences in motivation and academic performance, but little of this research has examined knowledge transfer. One aim of the current work is to begin to bridge these two literatures by examining the effect of individual differences in student motivation, operationalized as achievement goals, on knowledge transfer.

Achievement goals are the reasons people have for engaging in competence-based achievement settings, such as academics or sports (Covington, 2000). The prevailing way of classifying achievement goals is a 2 (mastery/performance) × 2 (approach/avoidance) framework that has been well-validated (Elliot & McGregor, 2001; Elliot & Murayama, 2008). This model separates the evaluative criterion (mastery or performance) from the focus (approach or avoidance), which results in four distinct goals (mastery-approach, mastery-avoidance, performance-approach, and performance-avoidance). Mastery goals refer to a person’s aims to develop his or her competence in comparison to an internally-referenced expectation or intra-personally defined prior levels of competence, while performance goals refer to a focus on demonstrating ability, often in comparison to a normative standard — that is, in comparison to others. Approach goals refer to seeking positive outcomes, while avoidance goals refer to averting negative ones. The literature on achievement goal theory shows that these goals lead to different patterns of affect, interest, and achievement (Harackiewicz, Barron, Pintrich, Elliot, & Thrash, 2002), and that mastery-approach goals may be particularly predictive of learning in more complex environments and on more conceptual tasks (Senko, Hulleman, & Harackiewicz, 2011; Utman, 1997). However, very little is known about the relationship between a student’s achievement goals and what is learned from a given learning activity, as well as whether or not that knowledge will transfer to a new task or situation (Pugh & Bergin, 2006). Are some goals better predictors of knowledge transfer and future learning than others? What

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instructional factors affect students’ achievement goals and whether or not a student adopts a particular goal for a specific learning or test task?

To begin to address these questions we have conducted a series of laboratory studies in which we have measured students’ achievement goals and examined their relationship to learning and knowledge transfer. In past work we found that the degree to which students reported being mastery-approach oriented toward mathematics predicted how likely they were to transfer a statistics concept from learning to test (Belenky & Nokes-Malach, 2012). In addition to using a well-established self-report measure of achievement goal orientation (Elliot & McGregor, 2001), we also developed and tested a “task-based” goal activity questionnaire to measure students’ achievement goal adoption for the specific learning task. We found that a form of structured inquiry instruction (Colburn, 2000; Roll, Holmes, Day, & Bonn, 2012) – which is referred to throughout as an “invention” activity – in which students first attempted to invent the necessary statistical procedures for the task resulted in increased task-based mastery goals compared to a more standard form of direct instruction called “tell-and-practice,” in which students were first shown a method for solving those types of problems and then given an opportunity to practice it on a new problem. Furthermore, we found an interaction between students’ achievement goal orientation and the type of instruction, such that students who were low in mastery-approach goal orientation in the invention condition were equally likely to transfer as those high in mastery-approach orientation, whereas those given direct instruction were only likely to transfer if they were already high in mastery-approach goal orientation. This interaction suggested that the type of learning activity affected students’ achievement goal adoption during the learning task, which impacted the likelihood of later transfer.

In the current study we build directly on this past work in two ways. First, we aim to provide a further test of the hypothesis that higher mastery-approach goal orientations lead to better transfer from instruction whereas the other goals do not. Very few studies have documented this relationship and it is critical to provide further evidence that these different goals are related to different cognitive outcomes. Furthermore, cognitive psychology research on knowledge transfer has a long history of predictions of high levels of transfer that are not supported by empirical observations (e.g., Bassok & Holyoak, 1989; Gick & Holyoak, 1980; Reed, Ernst, & Banerji, 1974). Establishing stable individual differences that predict transfer could help researchers better understand transfer processes and outcomes (Nokes & Belenky, 2011; Perkins & Salomon, 2012). Second, we aim to test the role of instructional activities in the adoption of task-based goals to see how these effects interact with existing motivation to influence transfer. We extend our past work by examining the effect of framing instructions for the learning activity (mastery versus performance) in addition to the effect of the structure of the learning activities (invention versus tell-and-practice) on goal adoption and transfer. We will briefly elucidate how each of these aims fit into the broader existing literature on achievement goals and transfer, as well as to more fully describe the Belenky and Nokes-Malach (2012) study, which this work builds upon.

1.1. Transfer and mastery-approach goals

Research investigating the validity and reliability of achievement goal self-report surveys has provided much evidence that each goal represents a separate psychological construct and that students can have varying degrees of each goal for any given achievement domain (Bong, 2001; Elliot & Murayama, 2008). Based on these analyses many researchers have investigated the independent contribution of each goal (or their interaction; Harackiewicz et al., 2002) for predicting some outcome measure. This research tradition has led to the identification of a consistent pattern of research findings for each of the goals, in terms of what affective experiences, behaviors, and academic outcomes they are related to, which we describe next.

Performance-avoidance goals have been correlated with a host of negative behaviors, feelings, strategies, and outcomes. For example, they are related to disorganized study behaviors and shallow processing strategies (Elliot & McGregor, & Gable, 1999), test anxiety (Elliot & McGregor, 1999), lower interest (Elliot & Harackiewicz, 1996), and lower grades (Elliot & Church, 1997). Performance-approach goals have been associated with a mix of both positive and negative outcomes. On the positive side, they are often correlated with academic outcomes, such as grades (see Harackiewicz et al., 2002). However, on the negative side they have been correlated with more shallow study strategies (Elliot et al., 1999), test anxiety (Elliot & McGregor, 1999), and a dependence on high evaluations of ability, without which the learner may shift toward performance-avoidance goals (Middleton, Kaplan, & Midgley, 2004). Mastery-avoidance goals have only recently begun to receive empirical investigation so a consistent pattern of results has yet to emerge (Madjar, Kaplan, & Weinstock, 2011; Richey & Nokes-Malach, 2013; Van Yperen, Elliot, & Anseele, 2009).

Because we are interested in studying how different paths of successful learning affect what knowledge is gained, our work focuses on mastery-approach goals, as these have been correlated with positive outcomes expected to influence transfer. Specifically, mastery-approach goals have been correlated with outcomes such as intrinsic motivation, interest, better self-regulation, and deeper strategy use (Ford, Smith, Weissbein, Gully, & Salas, 1998; Harackiewicz, Durik, Barron, Linnenbrink-Garcia, & Tauer, 2008; Somuncuoglu & Yildirim, 1999). In addition, they are associated with more positive affective experiences, such as feelings of challenge in response to difficulties (Elliot & Dweck, 1988). These learning processes, affective experiences, and outcomes are hypothesized to be important to learning in a way that produces knowledge transfer (Nokes & Belenky, 2011; Nokes-Malach & Mestre, in press), but little empirical evidence exists that documents the direct influence of mastery-approach goals on transfer (Pugh & Bergin, 2006). In fact, mixed effects have been observed for mastery-approach goals on achievement measures such as exam scores or final semester grades (see Harackiewicz et al., 2002; Linnenbrink-Garcia, Tyson, & Patall, 2008). A recent review found that about 40% of studies that investigated the relationship between mastery-approach goals and achievement found a significant positive correlation between the two variables (Linnenbrink-Garcia et al., 2008), indicating that a majority of studies do not find evidence for a benefit of mastery-approach on achievement.

There are several potential explanations for this pattern of results. It is possible that mastery goals lead to studying that is focused on what the person finds interesting, rather than what they expect to be on the test (Senko & Miles, 2008), or that mastery-approach goals which are adopted for social desirability reasons (e.g., wanting to please the teacher) may not be as effective in promoting learning as an exclusive focus on improving one’s competence (Darnon, Dompnier, Delmas, Pulfrey, & Butera, 2009). Another possibility is that the mastery-approach oriented students acquire a deep understanding of the materials, but the tests (e.g., multiple-choice exams) do not assess this type of learning. This idea has been called the “depth-of-learning” hypothesis (see Senko et al., 2011), and it proposes that students with mastery-approach goals do indeed learn the material in a “deeper” way — that is, they gain more conceptual, abstract knowledge which is likely to transfer — but this does not lead to increased achievement because the achievement measures themselves do not assess these types of learning outcomes.

The study reported in Belenky and Nokes-Malach (2012) found some initial evidence for this hypothesis. Specifically, we tested the influence of existing mastery-approach goal orientation for math on transfer and examined how this motivation interacted with two different types of instruction, invention and tell-and-practice. We measured transfer using the “Preparation for Future Learning” paradigm
developed by Bransford and Schwartz (1999) and Schwartz and Martin (2004) (see Fig. 1). In this paradigm, transfer is measured through a student’s ability to transfer knowledge from instruction to a new opportunity to learn (i.e., the learning resource) and then to use that knowledge to solve a new problem or perform a novel task (captured by the two inside lines in Fig. 1). This is in contrast to a more “traditional” method of measuring transfer, which focuses on testing how knowledge gained from instruction is directly applied to a novel transfer problem (captured by the outside lines in Fig. 1).

We provided instruction on basic procedures and concepts in statistics, like how to calculate mean deviation. Students were then given an assessment that included a critical transfer problem that required the calculation of a standardized score (although the problem did not explicitly say so). Half of the students in each instructional condition also received an embedded learning resource in the assessment (inside lines of Fig. 1). Specifically, they received a problem which included a worked example and explanation of how to calculate a standardized score. The critical measure of transfer is whether the instruction prepared students to learn from the worked example in such a way that they would transfer their knowledge to the target transfer item. Those given the learning resource were much more likely to solve the problem than those not given the resource. Furthermore, there was a clear pattern that higher levels of existing mastery-approach goal orientation for math predicted better transfer (see Fig. 2). This is evidence that students’ mastery-approach goals influenced what they learned from the different learning activities and subsequently affected the likelihood of knowledge transfer. Critically, no other achievement goal orientations were predictive of transfer. No prior research had demonstrated such a direct link between motivational orientation and transfer, particularly in an academic learning domain.

In addition, we manipulated the type of instruction (which we refer to henceforth as the “structure” of the learning activity) that students received by giving them either invention or tell-and-practice activities as they learned, as described above. Although there was no main effect of either type of structure on transfer, there was an interesting interaction between existing mastery-approach and the type of learning activity a student engaged in. Specifically, for the tell-and-practice condition, the likelihood of transfer was strongly related to the amount of mastery-approach goal orientation for math one endorsed, but for the invention condition, the relationship was mitigated. Only those students high in mastery-approach goal orientation were likely to transfer from tell-and-practice instruction, while all students in the invention condition were about equally likely to transfer, regardless of their mastery-approach goal orientation. To help understand this result, we next turn to how the different structures influenced goal adoption for the task.

1.2. Task-based mastery goal adoption

In our previous study we administered a task-based questionnaire during the course of the learning activities that asked students about the goals they focused on. Although achievement goal orientations are considered stable constructs (Elliot, 1999), they can be influenced by features of the environment (Ames, 1992), or by framing manipulations (Elliot & Harackiewicz, 1996). The activity questionnaire was an attempt to measure this spontaneous and task-specific goal adoption. The invention students reported adopting more mastery goals for the task than those who completed tell-and-practice activities. The open-ended nature of the activities seemed to prompt students to become more focused on developing their understanding in the course of solving the problems.

These results, paired with the interaction of task structure and goal orientation discussed above, provided initial evidence that having mastery-approach goals was beneficial for transfer, and that these goals could come from either an existing disposition (students high in mastery-approach orientation in the tell-and-practice condition) or from engaging with certain types of instruction (students adopting task-based mastery goals in the invention condition). If mastery-approach goals promote positive learning outcomes, what is the best way to facilitate their adoption if students do not have them already?

The current study explores the issue of what factors affect goal adoption in a task and the subsequent effects on transfer. We investigate whether framing manipulations can affect the goals students adopt for the learning task. If manipulating framing produces effects similar to those structure produced in Belenky and Nokes-Malach (2012), it would offer an easy way to promote adoption of the desired goals and increase the likelihood of positive transfer outcomes.

Prior research has shown that framing can be used to manipulate achievement goals in laboratory experiments. Specifically, researchers have manipulated goal adoption by giving different types of instructions about the scope, purpose, and utility of the task or activity (e.g., Elliot & Harackiewicz, 1996; Elliott & Dweck, 1988; Graham & Golan, 1991). For example, mastery goals have been induced by instructing participants that the learning materials would help them improve their skills or knowledge (Bereby-Meyer & Kaplan, 2005), even if they face difficulties or make errors (Elliot & Dweck, 1988). In contrast, performance goals have been induced by instructing participants that the task is reflective of their underlying ability for the domain (Graham & Golan, 1991) or that their performance would be compared to others’ performance (Elliot & Harackiewicz, 1996), and so the participant should strive to do well (for performance-approach) or avoid doing poorly (for performance-avoidance).

It may be possible and preferable to manipulate the framing of the instruction rather than to change the structure of the task, as framing has been manipulated with relatively simple interventions (e.g., Elliot, Cury, Fryer, & Huguet, 2006; Graham & Golan, 1991). However, the existing research on these framing manipulations has focused on

![Fig. 1](image1.png)

**Fig. 1.** The preparation for future learning paradigm, with the instantiated forms of this paradigm from Schwartz and Martin (2004) in parentheses. Adapted from Schwartz and Martin (2004, p. 184).

![Fig. 2](image2.png)

**Fig. 2.** The predicted probability of transfer as a function of mastery-approach orientation score. From Nokes and Belenky (2011, p. 128).
outcomes relating to performance on simple, novel laboratory tasks (e.g., Elliott & Dweck, 1988), or outcomes relating only to affective experiences with no measurements of performance (e.g., Elliot & Harackiewicz, 1996). These studies do not examine learning and do not consider how different goals might predict performance on tasks that require different amounts of prior knowledge or different levels of cognitive processing (cf. Graham & Golan, 1991). It is unknown whether this type of manipulation can be successfully used for academic domains such as mathematics, in which college students have much prior experience.

Further empirical research on the issue of framing is important, both for theoretical and practical reasons. A fully realized theory of achievement goals should be able to make predictions about how a given achievement goal will influence specific learning outcomes, such as transfer. Additionally, the theory needs to be precise about whether the effects of achievement goal orientations for a given domain are the same as framings for a given task. Furthermore, the importance of achievement goals on academic outcomes would be validated if effects of framing similar to those already observed on non-academic tasks can be observed on more academically relevant tasks, such as mathematics instruction, with measures of transfer. However, if these framing manipulations do not generalize beyond non-academic laboratory tasks then achievement goal theories need to take this into account. Practically, if the framing approach is successful with academic tasks, an instructor could simply change the framing and rationale of a classroom activity to encourage mastery goal adoption. For example, telling students that a certain activity is helpful for developing understanding (mastery framing) would lead to different processing and knowledge than telling students that the activity evaluates their ability (performance framing).

### 1.3. Questions and hypotheses

We investigated how achievement goals influence and are influenced by different activity structures (invention vs. tell-and-practice) and framings (mastery vs. performance) to support or inhibit knowledge transfer. By using the same learning activities as previous work and by manipulating the framing we could examine the relative contribution of each factor on transfer. Prior evidence suggests that goals activated during the task, whether due to individual dispositional differences or adopted in response to task structure or framing, could influence the type of the knowledge gained from instruction. We examined three questions related to this issue.

First, what is the relationship between achievement goal orientations and transfer? We expected that existing mastery-approach goal orientations would positively predict transfer, whereas the other goals would not. Only a few studies have directly examined this relationship (e.g., Bereby-Meyer & Kaplan, 2005), but we expected to see a similar effect as observed in our prior work (Belenky & Nokes-Malach, 2012). Specifically, we expected students who entered the experiment high in mastery-approach goal orientation would successfully transfer regardless of the structure or framing of the activity.

Second, how do the factors of structure (invention vs. tell-and-practice) and framing (mastery vs. performance) affect mastery-related goal adoption during the task? We predicted that invention activities would promote more mastery-approach goal adoption than tell-and-practice activities. In terms of framing, we predicted that a mastery framing would lead to more task-based mastery goals than a performance framing. However, we also predicted that this effect would be smaller than the effect of structure because the framing instructions might be ignored, downplayed, dismissed, or simply short-lived after the student begins to work on the learning activity. In contrast, the structure is inherent to the activity, so it is present throughout and is, therefore, likely to exert more influence on goal-setting. Put simply, asking students to perform an activity in order to improve their understanding is probably not as effective as creating an activity that promotes a desire for understanding by engaging in the activity.

Third, how does the structure and framing interact with a student’s initial mastery-approach goal orientation to affect transfer? Though higher levels of existing mastery-approach goals were predicted to improve transfer regardless of learning activities or framing, some combinations of these factors may produce better transfer than others for those who enter low in mastery-approach goals. Among those lower in mastery-approach goals who may otherwise not engage in a way that leads to transfer, what combination of instructional activities and framing is beneficial? Because this is an exploratory question strong prior predictions are not offered. However, we will highlight some of the more interesting possibilities.

One possibility is that crossing mastery framing with tell-and-practice instruction would produce the best transfer, as all of the necessary component skills are given in the tell-and-practice materials. The addition of the mastery framing may lead students to think deeply about these given skills during acquisition, leading to more abstract knowledge that transfers. Another possibility is that matching invention activities with mastery framing would lead to the best transfer, as the open-ended instruction paired with directions to focus on developing skill may lead students to engage in a constructive way with the learning materials, with no fear of negative evaluation of their abilities. Conversely, pairing open-ended invention activities, which require deep engagement with the underlying concepts of the problem, with a performance framing may lead students lower in mastery-approach goals to try very hard on the problem, based on the desire to do well and have validation of their ability. Even though they will inevitably struggle to solve the problem on their own, this sort of engagement may help those students to transfer.

### 2. Methods

This study closely followed the methods and materials of prior studies (Belenky & Nokes-Malach, 2012; Schwartz & Martin, 2004). Participants completed a pre-test, a series of learning activities on basic statistical concepts, and a post-test in a two-hour laboratory session. They were given questionnaires at the beginning, middle, and end of the experiment.

#### 2.1. Participants

Ninety-eight undergraduates from the University of Pittsburgh participated in this study (M = 19.4 years old, SD = 2.5 years) in exchange for course credit in their Introduction to Psychology course. Participants volunteered to participate and scheduled an experimental session online, based on a small posting describing the purposes and methods of the study. Forty percent of the participants were male, 33% were female, and the rest did not indicate their gender on a demographic sheet. Eighty-one percent had previously taken at least one statistics or calculus course. Eighty-eight percent of the participants spoke English as their first language. This study was approved by the University of Pittsburgh’s Institutional Review Board.

#### 2.2. Design and materials

This study had a 2 (structure: invention or tell-and-practice) × 2 (framing: mastery or performance instructions) between-subjects design. Participants were randomly assigned to one of the four conditions; Tell-and-Practice/Performance (n = 25), Tell-and-Practice/Mastery (n = 24), Invention/Performance (n = 24), and Invention/Mastery (n = 25). Materials were presented as packets in binders, which contained questionnaires, a pre-test, learning activities, a post-test, and a demographic sheet.

#### 2.2.1. Learning materials

The learning materials consisted of an activity on variability, followed by instruction on the calculation of mean deviation (a
narrated PowerPoint video), and then an activity on standardization. Fifteen minutes were allotted for each of these three components. Students were not provided with the solutions to the variability and standardization activities.

2.2.1.1. Variability activity. The first learning activity presented four different data sets representing the spread of a number of pitches thrown by different pitching machines. The students’ task was to decide which of the machines is the most reliable (see Fig. 3). The invention and tell-and-practice students both attempted to solve this problem, but the written instructions each received as part of the problem were different. Immediately prior to attempting the problem, the tell-and-practice group was given a worked example demonstrating how to calculate mean deviation (see Fig. 4) and was told to use that procedure in attempting to solve the problem. The invention group was not given this worked example, and was given the following instructions:

“Your task is to invent a procedure for computing a quantity that expresses the variability for each of the pitching machines and decide which is most reliable. There is no single way to do this, but you have to use the same procedure for each machine, so it is a fair comparison.”

Both groups were given access to scrap paper and a calculator during this activity.

2.2.1.2. Video. The video demonstrated a brief introduction on variability before walking through the calculation of mean deviation in a worked example. This was followed by two simple problems to work on, with solutions given to make sure students understood the basics of the formula. These problems asked students to use the formula to decide which of the two small data sets (six data points or less) was more consistent.

2.2.1.3. Standardization activity. The structure of the standardization activity was similar to the variability activity. The invention group was asked to evaluate which of two world records was “more shattered,” given two small data sets and the corresponding world record for each. The tell-and-practice group was given the exact same problem to solve, but was first shown how to graphically arrive at a solution through a worked example, which demonstrated how to create a visual representation (i.e., a histogram) of the distributions to arrive at a solution.

2.2.2. Framing

Framing was manipulated across the instructional conditions. Immediately below the tell-and-practice or invention instructions for each of the variability and standardization activities, participants saw text about the purpose of the task. These were constructed to promote either mastery or performance goal adoption while working on the learning activities. The framing instructions were modeled on previous work that had experimentally manipulated goals (i.e., Elliot & Harackiewicz, 1996; Elliott & Dweck, 1988). The mastery goal framing was:

“Many people see problems like this one as a challenge, and feel like they are developing their skill to solve these types of problems. While working on this problem, you may make mistakes and feel a little confused at times, but in the end you will have learned some things and developed your skill to solve problems like this one.”

The performance goal framing was:

“This problem assesses your mathematical ability. People who can solve this problem generally have the capability to solve similar problems. While working on this activity, you can gauge how good you are at these types of math problems.”

These instructions were underlined to make them more salient. Given the success of prior studies in students comprehending the manipulation (e.g., 95% choosing the correct goal in a manipulation check in Elliot & Harackiewicz, 1996), these manipulations were administered without a manipulation check.

2.2.3. Test materials

2.2.3.1. Test problems. The pre-test consisted of three items: a procedural skill measure, a data representation problem, and a transfer problem. The post-test contained isomorphic versions of these problems, as well as an adaptive use and a qualitative reasoning problem. Analyses will

![Fig. 3. The graphical representation of data given as part of the pitching machines problem, which students solved during the variability learning activity. Adapted from Schwartz and Martin (2004, p. 133).](image-url)
focus exclusively on the transfer measure, as we predict that differences relating to mastery-approach goals will specifically influence that form of knowledge. The two isomorphic transfer problems were both word problems that presented descriptive statistics for two data distributions and one exceptional score from each, and asked which individual score was more impressive. Though similar to the standardization activity, this problem assesses transfer, as it requires reasoning from descriptive statistics, not raw data, and because the problems were constructed so that simpler heuristic processing would lead to an incorrect answer (i.e., choosing the smaller range, or choosing the higher value). This problem was scored dichotomously, with an incorrect response labeled a "0," and a "1" being assigned if the participant calculated a standardized score correctly and used it to decide which value was more impressive.

2.2.3.2. Worked example. Also included in the post-test was a worked example on how to calculate a standardized score (see Fig. 5). This was presented just like the other test problems and described a situation in which one would want to calculate a standardized score to compare values from different samples. The text then introduced the formula to do so and computed the values for the data presented. This was followed by a second, very simple data set and asked the students to use the formula on these data. All participants were able to solve this simple problem correctly. The worked example always came at least two problems before the transfer problem, so if a student used the formula on the transfer problem, it was because they noticed that it applied and could recall it, not due to mere temporal contiguity. In contrast to prior work that experimentally manipulated the presence or absence of this resource in the test, all participants received the worked example. This was done because we are most interested in seeing how successful transfer occurs, and prior research has shown that learners generally do not do well on the transfer problem without the resource (Belenky & Nokes-Malach, 2012; Schwartz & Martin, 2004).

Here you will learn a technique for calculating how reliable a set of data is, by computing how variable it is. To do this, you must first calculate the mean. For example, take the data set:

| $x_i$ | $|\text{Mean} - x_i|$ |
|---|---|
| 26 | 10 |
| 27 | 9 |
| 27 | 9 |
| 28 | 8 |
| 29 | 7 |
| 36 | 0 |
| 45 | 9 |
| 47 | 11 |
| 47 | 11 |
| 48 | 12 |

The mean of this set is 36, which is calculated by adding up all of the elements and dividing by the number of data points in the set. That is, we add $26 + 27 + 28 + ... + 48$, which equals 360. We then divide by 10, since there are 10 values in the data set. This gives us a mean of 36.

To calculate the variability, you need to calculate how far each value is from the mean. Because we do not want to end up with negative values, you should take only the absolute value of the difference of the data point from the mean. We can call this value the data point’s “deviation.” Doing so gives us the column of data shown to the right.

Now, you can find the mean of deviations. This will give you the average deviation, a measure of how variable the data is. In this case, the sum of all of the deviations ($10 + 9 + 9 + ... + 12$) equals 86. We divide this by 10 (since there are 10 values), and find that this data set has an average deviation of 8.6.

Fig. 4. The worked example given to the tell-and-practice group before attempting the learning activity on mean deviation.
STANDARDIZATION

A standardized score helps us compare different things. For example, in a swim meet, Cheryl’s best high dive score was an 8.3 and her best low dive was a 6.4. She wants to know if she did better at the high dive or the low dive. To find this out, we can look at the scores of the other divers and calculate a standardized score (see Table C1).

To calculate a standardized score, we find the average and the mean deviation of the scores. The average tells us what the typical score is, and the mean deviation tells us how much the scores varied across the divers. Table C2 presents the average and mean deviation values.

The formula for finding Cheryl’s standardized score is her score minus the average, divided by the mean deviation. We can write:

\[
\frac{\text{Cheryl's Score} - \text{average score}}{\text{Mean deviation}} \quad \text{or} \quad \frac{X - M \text{ of } x}{M \text{ deviation of } x}
\]

### Table C1

<table>
<thead>
<tr>
<th>Diver</th>
<th>High Dive</th>
<th>Low Dive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cheryl</td>
<td>8.3</td>
<td>6.4</td>
</tr>
<tr>
<td>Julie</td>
<td>6.3</td>
<td>7.9</td>
</tr>
<tr>
<td>Celina</td>
<td>5.8</td>
<td>8.8</td>
</tr>
<tr>
<td>Rose</td>
<td>9</td>
<td>5.1</td>
</tr>
<tr>
<td>Sarah</td>
<td>7.2</td>
<td>4.3</td>
</tr>
<tr>
<td>Jessica</td>
<td>2.5</td>
<td>2.2</td>
</tr>
<tr>
<td>Eva</td>
<td>9.6</td>
<td>9.6</td>
</tr>
<tr>
<td>Lisa</td>
<td>8</td>
<td>6.1</td>
</tr>
<tr>
<td>Teniqua</td>
<td>7.1</td>
<td>5.3</td>
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<td>Aisha</td>
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### Table C2

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<th>High Dive</th>
<th>Low Dive</th>
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<tbody>
<tr>
<td>Average</td>
<td>6.7</td>
<td>5.9</td>
</tr>
<tr>
<td>M deviation</td>
<td>1.8</td>
<td>1.9</td>
</tr>
</tbody>
</table>

Fig. 5. The first portion of the worked example on standardization. Adapted from Schwartz and Martin (2004, p. 177–178).

2.2.4. Motivation measures

Existing achievement goals were assessed using the Achievement Goal Questionnaire (AGQ; Elliot & McGregor, 2001). This 12-item scale has three items for each of the four achievement goal constructs. The questions were phrased to be specifically about math classes and were assessed on a 7-point Likert scale, with a higher value indicating stronger endorsement of that particular goal. A construct score was created for each motivational orientation by averaging the three items for each goal (see Table 1). The reliability was high for the mastery-approach, mastery-avoidance, and performance-approach constructs ($\alpha$s > .7). The performance-avoidance construct was somewhat lower ($\alpha$ = .60), but given that it was still at an acceptable level for a construct comprised of three items (Schmitt, 1996), and how well-established the construct and this measure are in the literature (e.g., Elliot, 1999; Elliot & Murayama, 2008), we feel confident in using this construct score in our analyses.

Task-based mastery goals were assessed with an eight-item activity questionnaire administered during the learning phase (the same as that used by Belenky & Nokes-Malach, 2012). Four of these items had to do with the participant’s mastery goal adoption during the learning activities and four of these had to with the participant’s affective experience. The four items pertaining to mastery goals had adequate reliability ($\alpha$ = .74), so an average score was constructed for each participant. This follows the analysis procedure established in Belenky and Nokes-Malach (2012). The four affect items assessed the participant’s affective state and had low reliability ($\alpha$ = .34). As such, they could not be combined into a scale, and are omitted from the results. Additionally, at the end of the study, the participants completed additional questionnaires — the AGQ again, and a questionnaire we were piloting.

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD</th>
<th>$\alpha$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mastery-approach</td>
<td>5.51</td>
<td>1.20</td>
<td>.84</td>
</tr>
<tr>
<td>Mastery-avoidance</td>
<td>3.96</td>
<td>1.38</td>
<td>.70</td>
</tr>
<tr>
<td>Performance-approach</td>
<td>5.03</td>
<td>1.67</td>
<td>.93</td>
</tr>
<tr>
<td>Performance-avoidance</td>
<td>5.25</td>
<td>2.70</td>
<td>.60</td>
</tr>
</tbody>
</table>
to assess how students reflected on their experience. This new questionnaire proved to have low reliability ($\alpha = .55$), and will be excluded from the results.

2.3. Procedure

The study was run in groups of up to six participants in a two-hour laboratory session, with all participants working individually on provided packets. Inside the packet was an initial motivation questionnaire, a pre-test, a learning activity on variability, the activity motivation questionnaire, space to work on problems presented in the video, a learning activity on standardization, a post-test, a final set of questionnaires, and a demographics sheet (see Fig. 6). Participants took as long as they needed to complete the questionnaires, with no one taking longer than 3 min for any one questionnaire. Both learning activities and the video took 15 min each, with the video being comprised of about 7 min of instruction, followed by two practice problems, each of which provided participants with 3 min to work on them before the solution was demonstrated. Participants were given 5 min for each of the three pre-test items and each of the six post-test items (including the worked example). If a participant finished any portion of the experiment early, they were asked to sit quietly, looking over their work, until time had elapsed and the experimenter instructed them to move on.

3. Results

The results will be presented in the same order as our hypotheses. Our first hypothesis was that existing mastery-approach orientations would predict transfer. As the transfer measure was scored dichotomously (correct or incorrect), we use logistic regressions to evaluate the likelihood of successful transfer based on existing mastery-approach goal orientation. To ensure that this effect is independent of the other goal orientations, their impact on the likelihood of transfer is also modeled.

The second set of hypotheses concerns the effect of the manipulations on mastery goal adoption during the learning activities. Specifically, we predicted that the invention structure would promote more task-based mastery goal adoption than tell-and-practice, and that the mastery framing would promote more task-based mastery goal adoption than the performance framing. Additionally, we predicted that the effect of invention activities would be larger than the effect of mastery framing. To examine these questions, we analyze students’ self-reported responses to questionnaires administered during the learning activities.

Finally, we were interested in exploring the interactions between structure, framing, and existing mastery-approach goal orientation for transfer. This was an exploratory analysis for which we made no strong a priori predictions. Throughout the analyses, an alpha level of $p < .05$ is used to evaluate statistical significance. We report effect

![Diagram](https://via.placeholder.com/150)

Fig. 6. Each line moving down represents the procedure for one of the experimental groups. From left to right, these are: invention activities with mastery framing, invention activities with performance framing, tell-and-practice activities with mastery framing, and tell-and-practice activities with performance framing.
sizes of Cohen’s $d$ where appropriate, with an effect considered small when $d$ is less than .2, moderate when $d$ is between .2 and .8, and large when $d$ is greater than .8 (Cohen, 1988). When logistic regressions are used, odds ratios are reported to indicate the effect size.

### 3.1. Transfer performance

As mentioned earlier, the transfer item asked students to decide which score was better, given two individual exceptional scores from two different distributions. This item was coded dichotomously as either correct or not, and, for a problem to be considered correct, the participant had to show that they calculated standardized scores in their work, and not simply chosen the correct response. Seventy-five percent of the participants solved the transfer problem correctly.

To evaluate our hypothesis that initial mastery-approach orientation would predict transfer, we entered the mastery-approach goal orientation score, as well as mastery-avoidance, performance-avoidance, and performance-approach goal orientation scores, as predictors in a logistic regression model with transfer as the outcome. Specifically, the model was:

$$\ln \left( \frac{P_{\text{transfer}}}{1 - P_{\text{transfer}}} \right) = f \left[ a + b_{\text{Mastery-Approach}} \times \text{Mastery-Approach} + b_{\text{Mastery-Avoidance}} \times \text{Mastery-Avoidance} + b_{\text{Performance-Approach}} \times \text{Performance-Approach} + b_{\text{Performance-Avoidance}} \times \text{Performance-Avoidance} \right]$$

All independent variables were centered to aid in interpretation of the coefficients (Jaccard, 2001). Two participants did not complete the initial motivation questionnaire (one in the Tell-and-Practice/Mastery condition, one in the Tell-and-Practice/Performance condition) and are excluded from this analysis.

This model was a significantly better predictor than a constant-only model, $\chi^2 (4, N = 96) = 14.95, p < .05$. The only coefficient that was significantly different from zero was the mastery-approach coefficient, $B = .22, \text{Exp} (B) = 1.25$. Wald’s $\chi^2 (1, N = 96) = 6.87, p < .05$. The odds ratio of this coefficient indicates that for every unit increase in mastery-approach goal orientation on the initial questionnaire, the odds that the participant successfully transferred on post-test increases by a factor of 1.25 (see Fig. 7). Additionally, the mastery-avoidance coefficient was a marginally significant negative predictor of transfer, $B = -.13, \text{Exp} (B) = .88$, Wald’s $\chi^2 (1, N = 96) = 3.28, p = .07$.

### 3.2. Task-based mastery goal adoption

The second set of hypotheses had to do with the effects of the manipulations on the adoption of task-based mastery goals. To assess this, a task-based mastery score was created by averaging the four items on the activity questionnaire and used as the dependent variable in a $2 \times 2$ ANOVA. Analysis revealed a medium effect size of structure on task-based mastery goal adoption, $F (1, 94) = 14.40, p < .05, d = .75$. Students who engaged in invention activities ($M = 3.69, SD = .84$) reported being more focused on mastery goals than those that engaged in tell-and-practice activities ($M = 2.99, SD = 1.01$). There was no effect of framing, $F (1, 94) = .74, ns$. However, there was a medium interaction of structure by framing, $F (1, 94) = 4.16, p < .05, d = .42$. A series of follow-up tests showed that this interaction was driven by the significantly lower task-based mastery goal adoption for those completing tell-and-practice activities with a performance framing, compared to each of the other groups, all ts (47) > 2.02, $p < .05$ (see Table 2).

### 3.3. Interactions between mastery-approach, framing, and structure on transfer

Before investigating the three-way interaction between variables, it is important to establish whether our two manipulations of structure and framing predict transfer on their own. A binary logistic regression was conducted to analyze the effect of structure and framing on transfer performance, as well as the interaction between these variables. The model being evaluated was:

$$\ln \left( \frac{P_{\text{transfer}}}{1 - P_{\text{transfer}}} \right) = f \left[ a + b_{\text{Structure}} \times \text{Structure} + b_{\text{Framing}} \times \text{Framing} + b_{\text{Structure-Framing}} \times (\text{Structure} \times \text{Framing}) \right]$$

This model was not significantly better than a constant-only model, $\chi^2 (3, N = 98) = 1.18, ns$. On their own, the manipulations did not seem to influence the ability of students to transfer from instruction, with participants transferring at similar rates across all four conditions. Specifically, there were no differences between the percentages of students who successfully transferred across the Tell-and-Practice/Performance (80%), Tell-and-Practice/Mastery (75%), Invention/Performance (67%), and Invention/Mastery (72%) conditions, $\chi^2 (3, N = 98) = 1.17$.

Next, to investigate the possibilities of an interaction between existing mastery-approach goal orientation, structure, and framing, all three variables were entered into a logistic regression equation.

#### Table 2

<table>
<thead>
<tr>
<th></th>
<th>Tell-and-practice</th>
<th>Invention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mastery</td>
<td>3.29 (1.40)</td>
<td>3.24 (1.09)</td>
</tr>
<tr>
<td>Performance</td>
<td>3.16 (1.25)</td>
<td>3.88 (1.15)</td>
</tr>
<tr>
<td></td>
<td>3.60 (1.19)</td>
<td>3.50 (1.18)</td>
</tr>
<tr>
<td></td>
<td>3.52 (1.23)</td>
<td>3.50 (1.18)</td>
</tr>
<tr>
<td></td>
<td>3.92 (1.12)</td>
<td>4.08 (1.14)</td>
</tr>
<tr>
<td>Activity goals</td>
<td>3.28 (1.10)$^a$</td>
<td>3.75 (1.83)$^a$</td>
</tr>
<tr>
<td></td>
<td>2.71 (1.85)$^b$</td>
<td>3.83 (1.85)$^b$</td>
</tr>
</tbody>
</table>

*Note. The Tell-and-Practice/Performance condition was significantly different than the other three conditions in a series of post-hoc $t$-tests, denoted by different superscript letters.*

---

Fig. 7. Predicted probability of transfer for a given mastery-approach orientation score, based on the logistic regression model with all four achievement goal constructs entered as predictors, with a linear trendline.
predicting transfer, with all possible interactions (three two-way interactions and the three-way interaction) entered. The mastery-approach goal orientation variable was centered to aid in interpretation (Jacard, 2001). The other goal constructs were excluded, as our earlier analyses indicated that they do not significantly predict transfer, and to simplify the model. Specifically, the model being evaluated was:

\[
\ln \left( \frac{P_{\text{Transfer}}}{1 - P_{\text{Transfer}}} \right) = a + b_{\text{Mastery – Approach}} + b_{\text{Mastery – Approach}} \cdot \text{Mastery – Approach} + b_{\text{Framing}} + b_{\text{Framing}} \cdot \text{Framing} + b_{\text{Interaction}} + b_{\text{Interaction}} \cdot \text{Interaction}
\]

This model was a significantly better predictor than a constant-only model, \( \chi^2 (7, N = 96) = 20.84, p < .05 \). Aside from the constant term, \( B = 2.46 \), Wald’s \( \chi^2 (1, N = 96) = 6.55, p < .05 \), only coefficients which included the mastery-approach goal orientation variable were significant. Specifically, the mastery-approach goal orientation coefficient \( B = .51 \), Wald’s \( \chi^2 (1, N = 96) = 4.63, p < .05 \), the interaction coefficient for mastery-approach and structure, \( B = -.53 \), Wald’s \( \chi^2 (1, N = 96) = 4.16, p < .05 \), and the three-way interaction coefficient for mastery-approach goal orientation, structure, and framing, \( B = .76 \), Wald’s \( \chi^2 (1, N = 96) = 4.02, p < .05 \) were significant.

To better understand this pattern of results we analyzed the interaction of framing with existing mastery-approach goal orientation separately for each structure. By comparing the results across these two structures the differences can be highlighted and aid the interpretation of the three-way interaction. First, a logistic regression model was conducted with the data from only those participants who completed tell-and-practice activities. Existing mastery-approach goal orientation (centered) and framing were entered as predictors, as well as their interaction, into a model predicting the likelihood of transfer. The model being evaluated was:

\[
\ln \left( \frac{P_{\text{Transfer}}}{1 - P_{\text{Transfer}}} \right) = a + b_{\text{Mastery – Approach}} + b_{\text{Framing}} + b_{\text{Interaction}} + b_{\text{Interaction}} \cdot \text{Interaction}
\]

This model was significantly different from zero, \( \chi^2 (3, N = 47) = 9.90, p < .05 \). The constant term was significantly different from zero, \( B = 2.46 \), Wald’s \( \chi^2 (1, N = 47) = 6.55, p < .05 \), as was the mastery-approach goal orientation coefficient, \( B = .51 \), Wald’s \( \chi^2 (1, N = 47) = 4.63, p < .05 \). Neither the coefficient for the framing variable, nor the coefficient for the interaction of framing and mastery-approach goal orientation was significant. The significant coefficient for mastery-approach goal orientation indicates that, for the tell-and-practice group, every unit increase in mastery-approach goal orientation corresponds to the odds of successfully transferring increasing by a factor of 1.66, regardless of the type of framing (see Fig. 8).

The same logistic regression model was conducted with the data only from those participants who completed the invention activities. This model was significantly different from zero, \( \chi^2 (3, N = 49) = 9.85, p < .05 \). In this model, the only coefficient that was significantly different from zero was the coefficient of the interaction term, \( B = .51 \), Wald’s \( \chi^2 (1, N = 47) = 4.63, p < .05 \). This interaction coefficient represents the effect of mastery-approach goal orientation scores in the mastery framing condition, as the performance framing condition was the baseline. This means that for those who received the performance framing with invention activities, there was almost no effect of mastery-approach goal orientation scores on their likelihood of transfer; the relationship was flat (see Fig. 8). However, for those who received the mastery framing with invention activities, there was a positive relationship between existing mastery-approach goal orientation and the likelihood of transfer, such that every unit increase in mastery-approach goal orientation increases the odds of successfully transferring by a factor of 1.62.

3.4. Activity goals and transfer

The prior analysis focused on the effect of existing mastery-approach orientations on transfer. However, it is possible that the degree to which a student adopts a task-based mastery goal during the learning activity is itself predictive of transfer. To investigate this possibility, task-based mastery goal adoption was entered as a predictor of transfer in a logistic regression. This model was not significantly better than a constant-only model, \( \chi^2 (1, N = 98) = .01, ns \). The degree to which students reported adopting a mastery-related goal for the task was, by itself, not predictive of transfer.

4. Discussion

4.1. Mastery-approach goals and transfer

This study found an effect of existing mastery-approach orientation on transfer, replicating a main finding of Belenky and Nokes-Malach (2012). Overall, students high in mastery-approach goal orientation at the beginning of the experiment were more likely to transfer from instruction to a target problem at test. In contrast, the other three achievement goals had no significant effects on the students’ likelihood of transfer. This result provides evidence that existing achievement goal orientations change what a student learns during the course of instruction. This finding provides support for the importance and utility of the mastery-approach achievement goal construct, and, in particular, its role in the development of knowledge that is conceptual and abstract enough to transfer to novel problem-solving situations. However, the results of this study also suggest that certain combinations of task framings and structures may influence the relationship between mastery-approach goal orientation and transfer. In particular, the results indicate that a performance framing with invention activities may be particularly beneficial for those who are lower in mastery-approach goal orientation. Before discussing this complex interaction,
however, we will first discuss the effects of our manipulations on transfer and goal adoption.

4.2. Experimental manipulations and transfer

In contrast to prior work (Schwartz, Chase, Opezzo, & Chin, 2011; Schwartz & Martin, 2004), we did not observe an effect of invention promoting transfer relative to tell-and-practice. There are a number of potential explanations for this difference. One distinction between our study and the prior work is that the samples were drawn from different populations; Schwartz’s studies have been conducted with middle and high school students, while our study used college students. College students may be better prepared to learn from tell-and-practice instruction because they have had more practice and experience in academic settings than a typical middle or high school student. In addition, there may be selection effects operating on the college population that are not operating in the younger grades (i.e., college admissions requirements). This could have led to the college students having higher general abilities (e.g., selected vis-à-vis SAT scores) or higher levels of motivation for academics than students in middle or high school. Any one of these factors or a combination of them may have given the college students a general learning advantage for either type of instruction, potentially minimizing the effect of invention compared to tell and practice. This possibility is supported by the levels of success seen in this study for the tell-and-practice conditions — approximately 75% of students transferring with the worked example — as opposed to theirs — approximately 25% (Schwartz & Martin, 2004). Additionally, participants in our study worked individually, while students in the Schwartz and Martin study worked in pairs or small groups. It is possible that the benefits of invention on transfer are particularly strong when students work in groups (Roll et al., 2012; Wiedmann, Leach, Rummler, & Wiley, 2012). There is also a difference in contexts between the studies. Specifically, the current study was conducted in a laboratory setting, while Schwartz and colleagues (Schwartz & Martin, 2004; Schwartz et al., 2011) have conducted studies in classroom settings, and have found effects of invention on transfer. Finally, the time scale of instruction was different. In our study, participants worked for a short amount of time on the learning activities (45 min), but in Schwartz and colleagues’ work, students work on and discuss invention activities over multiple class periods (e.g., 6 h over two weeks; Schwartz & Martin, 2004). The present study’s compressed time scale may have led participants to feel mentally tired (i.e., to experience “ego depletion”; Baumeister, Bratslavsky, Muraven, & Tice, 1998), as they completed a number of learning and test activities in a relatively short period of time. This may have hindered transfer for the invention condition, in particular, relative to prior studies. The invention activities require more constructive processing and active engagement, and, for typical students in these studies, involve the evaluation of many different (unsuccessful) solution paths. Given the short amount of time between the learning and test phases of the present work, the mentally taxing experience of the invention activities may have possibly lowered the amount of attention and energy available to the participant when they arrived at the transfer problem, near the end of the study.

Any or all of these differences could potentially explain the different pattern of results observed in this study, compared to prior research. In addition to this result, no main effect of task framing was observed on transfer; this will be discussed in light of the complex interaction between factors in a subsequent section.

4.3. Experimental manipulations and task-based mastery goals

Although the invention task structure did not have a direct effect on transfer, it did influence the adoption of task-based mastery goals during the learning activity. Overall, invention activities led to more task-based mastery goal adoption than tell-and-practice activities. It appears that the open-ended nature of the invention activities leads students to focus on their own understanding in a way that a more standard, tell-and-practice mode of instruction does not. In contrast, task framing only interacted with structure to affect task-based goal adoption. The way in which a task is framed seems to matter more for some types of activities than others. Specifically, students who received tell-and-practice activities with a performance framing had the lowest levels of task-based mastery goals. This result suggests that receiving direct instruction on a formulaic procedure and practicing it while focusing on performing the procedure well does not promote the adoption of task-based mastery goals in students.

Observing this result in a short laboratory study suggests that task-based mastery goal adoption may be quite low in typical classrooms, which may not involve structured inquiry or mastery framings, leaving it up to students’ internal dispositions to determine whether or not to process the material deeply. A more optimistic interpretation of this effect would be that changing some aspects of the instruction can influence students’ task-based mastery goal adoption. The other three conditions in this study all had some element that influenced mastery, either through framing instructions or the structure, and all reported higher levels of mastery-related goal adoption. Note that these effects were not additive; the Invention/Mastery group was not higher in task-based mastery goal adoption than the Invention/Performance group, or the Tell-And-Practice/Mastery group. Additionally, while the activity questionnaire we have used appears to work well in this environment, it may be overly specified to detect differences between these task structures. Specifically, it focuses on students’ desire to understand the problem-solving procedure they are using, something that is very salient during invention activities, but likely less so in other forms of instruction. Future research should develop and validate measures of task-based goal adoption, to help clarify exactly what effect existing motivational orientations, task structures, and framings have on the goals a student adopts in a given setting.

4.4. Interaction between mastery-approach orientation, structure, framing and transfer

A complex interaction between students’ existing mastery-approach achievement goal orientations, structure, framing, and transfer was observed in the current study. All of the conditions except invention with a performance framing followed the same general pattern, with mastery-approach goal orientation predicting the likelihood of transfer. The finding that highly mastery-oriented students transferred well from tell-and-practice activities with performance-oriented framing seems particularly important for educational purposes. That is, these students may be very practiced at satisfying their desire for understanding in the context of evaluative demands, such as those seen in the course of normal schooling. Perhaps mastery-oriented students have become experts at balancing the demands of multiple goals while still achieving robust learning. For example, they may have developed methods to learn the material in ways that satisfy both the evaluative demands of the classroom and their own desire for understanding and improved competence. This research highlights the importance of taking into account individual differences in motivation for learning and transfer. That is, this study presents an instance where some students can perform well and some cannot, depending on an existing difference in their achievement goals. A productive research agenda for future investigation would be to examine the joint effect of existing motivation for a domain and other individual differences on learning, and, in particular, on learning from various types of instruction.

This study also contributes the novel result that the relationship between mastery-approach orientation and the likelihood of transfer was flat for the condition that received invention with performance framing. This can be viewed in two ways. In one view, this finding indicates that the evaluative context facilitated by the performance framing seems to have disrupted learning for high mastery-oriented
learners. We may not see evidence of this on the goal adoption measures because of the particular way that measure is constructed. Specifically, the questions on the activity questionnaire are focused on task-based mastery goals, but it is possible the evaluative context promoted an increase in performance goals, as well, which are orthogonal to the mastery goals we were assessing. The performance framing manipulation drew heavily on the idea of assessing ability, something that was not captured in the activity questionnaire. It is possible that keeping an ability-focused evaluation in mind increased performance goals (either approach or avoidance), which may have been detrimental to highly mastery-oriented students. That is, the evaluative context may have made those students perform in ways that were more performance-oriented than they normally would, and, when paired with minimal guidance on a difficult problem, this hampered constructive learning processes. This is a speculative account, and more research is necessary to see which goals are more salient in given settings and how they coalesce or interfere with each other. A person-centered approach (e.g., Heikilä, Niemivirta, Nieminen, & Lonka, 2011) may also shed light on this issue by focusing on the effect of particular clusters of motivational variables, rather than treating each individually.

The other view of this result highlights that students who were lower in mastery-approach orientation were more likely to transfer in that condition. Viewed this way, this result can be considered a positive outcome. By framing a challenging, open-ended task as an ability measurement (i.e., performance framing), some students may feel motivated to put effort in, and as the task is open-ended, that effort gets focused in a way that aids in deeper processing. One interesting potential implication of this may be that performance framing, when paired with invention activities, may (counter-intuitively) lead to higher levels of mastery goals for the task. This conjecture is supported by the trend, observed on the activity questionnaire, that the group who completed the invention activity with performance framing had the highest level of mastery goal adoption in the task. That is, for low mastery-oriented students, the focus on evaluating ability in a challenging, open-ended task, may actually produce more mastery-approach motivation than would otherwise be expected, aiding their learning in a way that helps to transfer.

This account needs to be further examined in future studies and would be aided by research that identifies where the benefits for mastery-approach goal orientation on learning are to be found. It is possible that the relationship between these goals and learning observed in this and other studies is due to a correlated third individual difference variable, such as general ability or metacognitive skill. Understanding more about the exact nature of the relationship between mastery-approach goals and learning will help to make sense of differences between research approaches that examine mastery-approach goals as stable orientations versus dynamic and task-based, and how each may influence learning. Additionally, extending the type of method used here to classroom settings will be important. As a laboratory study, it is unclear how generalizable these results are to the types of learning behaviors and outcomes that achievement goals may lead to in classroom settings, or as students study for classroom-based assessments.

4.5. Mastery-approach goals: task-based vs. orientation

Although self-reported task-based mastery goals did not predict transfer, existing mastery-approach goal orientations did. This raises important questions about the relationship between these two measures. The activity questionnaire may be measuring a different construct than the AGQ (Elliot & McGregor, 2001). That is, the AGQ could be measuring more than achievement goals for a given domain. In particular, the questionnaire seems likely to be capturing dispositional characteristics related to achievement goals (e.g., need for cognition, Cacioppo & Petty, 1982; need for cognitive closure, Webster & Kruglanski, 1997; naive theories of intelligence, Dweck, 1999), whereas the activity questionnaire is more locally bounded and likely to be capturing a student’s proximal goal, based on the current setting (e.g., classroom effects, structure, framing, etc.).

4.5.1. Comparison of the framing manipulation to prior research

We did not observe a main effect of our task framing on goal adoption, even though one framing was designed to promote task-based mastery goal adoption. This manipulation did not appear to produce effects similar to existing predispositions. This stands in contrast to a small body of studies which have had success using such manipulations (e.g., Elliot & Harackiewicz, 1996; Elliot, Shell, Henry, & Maier, 2005; Elliot & Dweck, 1988; Senko & Harackiewicz, 2005), so it is valuable to note important differences between prior studies and the current one. For example, Elliot and Dweck (1988) sampled from a much younger population than the present study. However, other studies have used similar populations as the present study (e.g., Darnon, Butera, & Harackiewicz, 2007), so it is unlikely that this difference alone changed the pattern of results. A more likely reason for the differences is that the goal manipulation in prior studies frequently included aspects beyond just the task framings used in the current study. In the earlier research, the performance goal manipulation included being videotaped in order to be evaluated by experts, which differs from the purely normative focus thought to be a part of performance goals. Similarly, students in that study's learning (mastery) goal condition were told that the types of tasks they were engaging in would “sharpen the mind” and may aid in future studies, which may have induced a growth mindset (Dweck, 2006), rather than only affecting mastery goals. While the current study attempted to stay more closely linked to the achievement goal constructs, without a manipulation check, it is unclear to do what degree students did in fact adopt a “pure” mastery or performance goal. This is a limitation, which future research should examine. It is possible that achievement goal manipulations that incorporate other motivational constructs are more successful, but at a cost of theoretical precision.

Perhaps more critically, another difference between the current study and previous work is that most of the literature has focused heavily on performance measures, rather than measures of learning. A significant amount of the existing research has looked at the effect of manipulated achievement goals on the performance of some intellectual task, such as hidden figures puzzles (Elliot & Harackiewicz, 1996), finding words in a jumble of letters (Senko & Harackiewicz, 2005), or completing number patterns (Elliot et al., 2005). However, very few studies have looked at the effect on learning (cf. Bereby-Meyer & Kaplan, 2005). Perhaps the complexity of our instructional materials relative to previous experimental work led to a task environment that was less susceptible to small framing manipulations. This difference is important for achievement goal theory, and, in particular, for ensuring that the theory is ecologically valid. While a significant amount of research has chronicled the effect of existing goal orientations on what students report doing in classrooms, it is important to see the effects these goals have on learning processes and knowledge outcomes. Goal manipulations should continue to be refined and extended to a variety of learning and performance domains. In particular, more work needs to be done on whether framing manipulations can influence learning in classroom contexts. Evidence already exists that long-term interventions can have very profound effects on student learning, especially when they succeed in changing underlying beliefs, such as beliefs about the malleability of students' own intelligence (e.g., Blackwell, Trzesniewski, & Dweck, 2007; Good, Aronson, & Inzlicht, 2003).

4.5.2. Stability of achievement goals and goal adoption

The research presented here also highlights a fundamental tension that is present in the achievement goal literature concerning the stability of achievement goal orientation. Research has provided evidence that it is both stable over time and a dynamic variable that changes
over time (e.g., Fryer & Elliot, 2007), both easy to manipulate in the short term (e.g., Elliot & Harackiewicz, 1996), and needing intensive intervention to affect in the long term (e.g., O’Keefe, Ben-Eliyahu, & Linnenbrink-Garcia, 2012). Linking particular learning activities (i.e., invention) with variations in achievement goals for the task illustrates that there is much more to be understood about the moment-to-moment influences on achievement goals, including predispositions, prior experience, and environmental variables. It is clear that there are many potential sources of mastery goals, such as classroom grading structure, the types of learning activities used, and the amount of authority given to students (see Ames, 1992). Individual differences, such as naïve theories of intelligence (Dweck, 1999) and need for cognition (Cacioppo & Petty, 1982), are also likely to influence mastery goal adoption. A formalized model of these factors that could be empirically tested would help clarify the relative contributions of each component towards achievement goals for a given task. Such a contribution could also help to make sense of the finding in this study that, even though mastery-related goals varied in the different conditions, the degree to which students reported adopting these goals was not directly predictive of subsequent transfer. Instead, only existing mastery-approach goal orientations were predictive of transfer.

Future research is needed to systematically analyze the relationship between these different types of measures, because it is critical to determine how achievement goals influence learning and performance. How is an achievement goal selected for a given task? How do achievement goals change, both moment-to-moment and over longer periods? When one achievement goal is activated, how does this change a student’s pattern of learning behaviors? These questions will need to be addressed for achievement goal theory to continue being a dominant way of understanding student motivation in academic settings. These questions are important for both theoretical and practical reasons. Practically, educators need precisely this type of information to understand how to structure their classrooms and individual learning activities to maximize student motivation and learning. For theory to advance, researchers will need to increase the specificity of the predictions achievement goal theory makes, and to clarify exactly how different achievement goals are selected and used in any given setting.

5. Conclusion

The study of student motivation has much to offer researchers focused on how students learn. The goal a student has in a learning environment is likely to influence the form and utility of the knowledge acquired in that environment (Nokes & Belenky, 2011; Nokes-Malach & Mestre, in press). Specifically, the way information is represented and processed will have an effect on how that information is used to solve new problems and learn new concepts (e.g., Nokes & Ollsson, 2005). A student’s goals for a learning environment can be a catalyst for facilitating different types of processing and result in different types of knowledge, as demonstrated by mastery-approach goals predicting performance on transfer tests. The fact that we can reliably show these differences in a laboratory setting with classroom-like materials provides initial evidence that the effect of goals and their interactions with the instruction has important implications for classroom learning, especially since student goals should be even more salient (dominant) in actual classrooms. However, it will be important to replicate these results in in-vivo classroom studies, especially given the lack of consistent findings of a benefit for mastery-approach goals in academic settings. If this effect is robust and observed in a variety of settings using multiple measures of transfer, this would provide evidence for the “depth-of-learning” hypothesis (Senko et al., 2011). That is, one possible reason that mastery-approach goals are not always correlated with achievement may be that the achievement measures are not measuring the sort of deep, conceptual knowledge that mastery-oriented learners are developing. Using measures which assess the ability to transfer knowledge in academic settings like college classrooms may help make sense of this apparent discrepancy in the theoretical account. Future research should also explore the cognitive mechanisms by which achievement goals affect the type of learning. Evidence exists that mastery goals predict improved self-regulation, preference for challenge, and persistence (e.g., Grant & Dweck, 2003; Linnenbrink, 2005; Wolters, 2004), but work has not examined the underlying cognitive mechanisms. Potential accounts for improved learning with mastery-approach goals could be based on depth of processing (e.g., Graham & Golan, 1991; Watkins, 1983), self-explanation (e.g., Chi, Bassok, Lewis, Reimann, & Glaser, 1989), and schema formation (e.g., Anderson & Pearson, 1984; Judd, 1908; NRC, 2000), among others, and successful theories will need to incorporate these mechanisms for a complete account. Achievement goals remain an important individual difference to consider, and one that could greatly impact how we can use various subdomains of psychology – cognitive, social, educational, and personality – to improve education.

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