



Journal of the Learning Sciences

Publication details, including instructions for authors and subscription information:

<http://www.tandfonline.com/loi/hlms20>

Motivation and Transfer: The Role of Mastery-Approach Goals in Preparation for Future Learning

Daniel M. Belenky^a & Timothy J. Nokes-Malach^a

^a Learning Research and Development Center,
University of Pittsburgh

Available online: 19 Jan 2012

To cite this article: Daniel M. Belenky & Timothy J. Nokes-Malach (2012): Motivation and Transfer: The Role of Mastery-Approach Goals in Preparation for Future Learning, Journal of the Learning Sciences, DOI:10.1080/10508406.2011.651232

To link to this article: <http://dx.doi.org/10.1080/10508406.2011.651232>



PLEASE SCROLL DOWN FOR ARTICLE

Full terms and conditions of use: <http://www.tandfonline.com/page/terms-and-conditions>

This article may be used for research, teaching, and private study purposes. Any substantial or systematic reproduction, redistribution, reselling, loan, sub-licensing, systematic supply, or distribution in any form to anyone is expressly forbidden.

The publisher does not give any warranty express or implied or make any representation that the contents will be complete or accurate or up to

date. The accuracy of any instructions, formulae, and drug doses should be independently verified with primary sources. The publisher shall not be liable for any loss, actions, claims, proceedings, demand, or costs or damages whatsoever or howsoever caused arising directly or indirectly in connection with or arising out of the use of this material.

Motivation and Transfer: The Role of Mastery-Approach Goals in Preparation for Future Learning

Daniel M. Belenky and Timothy J. Nokes-Malach
Learning Research and Development Center
University of Pittsburgh

The study of knowledge transfer rarely draws upon motivational constructs in empirical work. We investigated how students' achievement goals interact with different forms of instruction to promote *transfer*, defined as preparation for future learning (Bransford & Schwartz, 1999). Students were given either invention or tell-and-practice activities when learning statistics concepts and their achievement goal orientations were measured at the beginning of the experiment. We also assessed students' goals during the learning activity. We predicted that students who entered the experiment with a high mastery-approach goal orientation would be more likely to transfer, regardless of instruction. We also hypothesized that invention activities would lead to higher mastery-approach goal adoption for the task and more attention to important conceptual features, as students would focus on trying to understand the material. Finally, because we expected that invention activities would promote mastery goal adoption during the task, we predicted a moderating effect of invention activities, such that there would be a smaller effect for students' initial mastery-approach goal orientation on transfer for those who invented compared to those who received tell-and-practice instruction. All three hypotheses were supported. Results are discussed in terms of contributions to research on knowledge transfer, achievement goals, and educational practice.

A central goal of the cognitive and learning sciences is to understand how, when, and why people transfer their knowledge from one situation or task to another. Research over the past 100 years in psychology has made some progress toward achieving this goal by developing specific accounts of transfer, such as the transfer of cognitive skills or the transfer of solutions from one problem to another (for

reviews, see Barnett & Ceci, 2002; National Research Council, 2000; Royer, 1979; Singley & Anderson, 1989). Much of this work has viewed transfer as the direct application of prior knowledge or skills to solve a new problem or perform a new task (Bransford & Schwartz, 1999). Although this “classic” view of transfer has helped to identify some of the underlying cognitive mechanisms, such as the role of analogy or schemas (Gick & Holyoak, 1980; Nokes, 2009; Reed, 1993), it has also shown mixed results and cases in which transfer did not occur as expected (e.g., Bransford, Franks, Vye, & Sherwood, 1989; Reed, Dempster, & Ettinger, 1985).

These mixed laboratory findings have inspired a number of alternative approaches that expand the idea of transfer beyond the direct application of prior knowledge (Bransford & Schwartz, 1999; Greeno, 2006; Lave, 1988; Lobato, 2006). These approaches have led researchers to examine the role of sociocultural factors and context in transfer (Greeno, 2006; Lave, 1988), to consider transfer as preparation for future learning (Bransford & Schwartz, 1999), and to focus on the individual who is transferring from an actor-oriented perspective (Lobato, 2003). Each of these alternative approaches provides some insight into and focuses attention on previously neglected aspects of transfer phenomena.¹ However, one aspect of transfer that has yet to be systematically explored in either the classic or alternative approaches is the relation of motivation to transfer. We believe that examining the role of motivation may help to shed light on prior findings and may prove to be a critical factor for understanding transfer.

To our knowledge no theories fitting the classic approach, an actor-oriented view, or transfer as preparation for future learning have explicitly integrated student motivation into their theories and approaches. The situated view has considered how issues of identity lead to whether or not people become engaged in participation (Greeno and the Middle School Mathematics through Application Project, 1998; Hickey, 2003), but even this work has not systematically investigated the role of motivation in knowledge transfer. In the current work we examine the role of motivation in a preparation for future learning experiment.

The first and primary aim of our work is to begin to explore the role of motivation in knowledge transfer, specifically focusing on how students’ achievement goals impact transfer. Although prior work in educational and social psychology has examined the role of achievement goals in student learning and performance, much work remains to link these goals to the underlying cognitive processes and to the types of knowledge they might produce. Prior work on achievement goal theory has delineated between mastery goals, which deal with the development of understanding and competence, and performance goals, which deal with the demonstration of skill (e.g., Dweck & Leggett, 1988; see Elliot, 2005, for a review

¹ Some theorists would argue that these alternative viewpoints are competitive explanations, but we view them as complementary. By considering the unique contributions of each, one is more likely to obtain a comprehensive view of transfer.

of this construct's history). Another dimension of the achievement goal framework is whether the goals are approach oriented, in which the learner focuses on obtaining a desired outcome, or avoidance oriented, in which the learner is concerned with averting an undesired outcome (Elliot, 1999). In the current work we focus on how mastery-approach goals affect what is learned. As we review here, the current literature suggests that mastery-approach goals should lead to constructive and reflective cognitive processes that will support positive outcomes in terms of conceptual learning and transfer.

A second aim of this work is to examine the effect of instruction on the adoption of mastery-related goals within a task. Prior work in the learning sciences has examined how students learn from invention activities (variously described as *structured inquiry* or *discovery*; Schwartz & Martin, 2004; see also Kirschner, Sweller, & Clark, 2006) and tell-and-practice activities (which consist of a form of direct instruction; Carroll, 1968; Klahr & Nigam, 2004; Nokes & Ohlsson, 2005). We examine how these two types of activities affect the adoption of mastery-related goals during the course of the instruction and how this affects learning behaviors and outcomes. We predict that invention activities will facilitate the adoption of mastery-related goals during learning as well as a greater focus on the conceptual features of the learning materials.

A third aim is to examine how existing mastery-approach goal orientations interact with different types of instruction. Although we predict that invention activities will facilitate mastery-related goal adoption, it is not clear how existing goal orientations will interact with this effect. Adopted mastery-related goals may only influence those who do not already possess strong mastery-approach orientations. In this case we would expect a moderation effect, such that the benefit of mastery-approach orientations is less for those who complete invention compared to those who complete tell-and-practice. Those in the tell-and-practice group should instead be dependent on their existing mastery-approach orientation to lead to knowledge that transfers.

To examine these predictions we conducted a laboratory experiment using Schwartz and Bransford's preparation for future learning paradigm with students learning basic statistics concepts (Bransford & Schwartz, 1999; Schwartz & Bransford, 1998; Schwartz & Martin, 2004). At the beginning of the experiment we measured students' existing achievement goal orientations in mathematics and assigned half of the participants to invention activities and half to tell-and-practice activities. We also measured their goals during the learning activity. Then participants went on to the test phase, in which they were given a transfer task. Half of the participants in each condition were given a learning resource (a worked example) during the test phase to determine whether the instructional intervention differentially prepared/motivated them to learn from the example and transfer their knowledge. Before describing the study in detail we expand on the two areas in which our work builds: transfer as preparation for future learning and achievement goal motivation.

TRANSFER AS PREPARATION FOR FUTURE LEARNING

Recently, Schwartz and colleagues (Bransford & Schwartz, 1999; Schwartz, Bransford, & Sears, 2005) proposed a novel distinction for two views of transfer, one as direct application of learned knowledge to a target problem and the other as preparation for future learning. Direct application of prior knowledge occurs when students produce an answer using either procedural or conceptual knowledge they have already learned. That is, they may either replicate prior procedures (replicative knowledge) or apply some conceptual understanding to solve a new problem (applicative knowledge). This type of direct application of prior knowledge, these researchers argue, is what traditional transfer studies have focused on measuring. As mentioned earlier, several of these classic studies reported no transfer or mixed results even in situations in which transfer was intuitively predicted (for a review, see Detterman, 1993).

In contrast, Schwartz and colleagues proposed focusing on transfer as preparation for future learning. This type of transfer depends on *interpretive knowledge* rather than replicative or applicative knowledge. This approach complements the direct application view; replicative and applicative knowledge can be measured by how knowledge “transfers out” to solve a new problem, but interpretive knowledge is best measured by testing how knowledge acquired in one situation “transfers in” and prepares students to learn from a new resource (e.g., instruction or activity).

To test the distinction between direct application and preparation for future learning in an experimental design they proposed the double transfer paradigm. This paradigm enables one to test how different types of instruction prepare students for future learning (see Figure 1; Bransford & Schwartz, 1999; Schwartz & Martin, 2004).

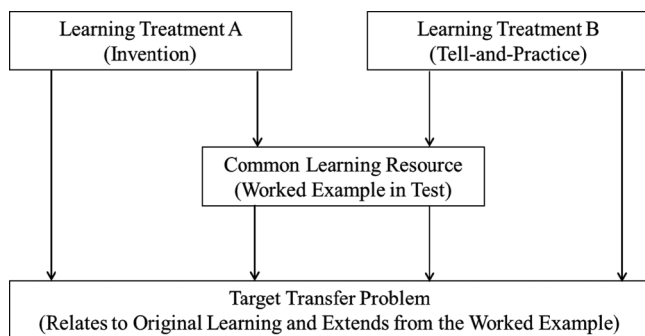


FIGURE 1 The preparation for future learning double transfer paradigm. The particular ways in which the paradigm was instantiated in Schwartz and Martin (2004) are included in parentheses. Adapted from Schwartz and Martin (2004, p. 184).

In this paradigm students are given one of two types of instruction and then complete a transfer problem, similar to the classic transfer experiments (i.e., the outside arrows in Figure 1). The novel wrinkle is that after the initial instruction half of the students in each instructional condition are given a new learning resource before the transfer assessment. These students (the inside arrows in Figure 1) are presented with an opportunity to use their initial learning to help them learn from this new resource, and then use that knowledge on the transfer problem.

Schwartz and Martin (2004) used this paradigm to compare invention activities to tell-and-practice. In their study, students completed a learning activity on the statistics concept of standardization that required them to compare two exceptional scores from different distributions and decide which was better. The tell-and-practice group was first shown a graphical method for determining standardization and was then asked to use that method to solve the problem. The invention group was given the same data but was asked to invent, on their own, a procedure to solve the problem. It is notable that the invention group struggled with this task and did not complete it successfully.

In the test phase all of the students were given a transfer problem that required them to reason about a similar type of problem, in which they again had to decide which of two values from two different distributions was more exceptional. This time, however, they were reasoning based on descriptive statistics rather than raw data. Half of the tell-and-practice group and half of the invention group received an embedded learning resource (a worked example) in the test, which demonstrated how to mathematically calculate a standardized score. The results showed an interaction, as the authors had predicted; students who invented and were given the worked example were the only group to perform well on the transfer problem.

Schwartz and Martin (2004) explained this finding as being due to the students in the invention condition creating more “well-differentiated” knowledge from the learning activities than the students in the tell-and-practice condition. That is, students given the invention activities were hypothesized to be more likely to think about and grapple with the various dimensions of the variability concept (e.g., range, number of observations, consistency) than students given the tell-and-practice activities. The invention students could then use this knowledge to learn more deeply from the worked example and thus perform better on the transfer task. However, other interpretations of this result are possible, and other factors may have played a role. For example, it is possible that the type of instruction also had an effect on students’ motivation and specifically on mastery goal adoption.

Prior work has shown that mastery orientation can be promoted in classrooms by different task structures, evaluation practices, and the distribution of authority (Ames, 1992; Ames & Archer, 1988; Urdan & Schoenfelder, 2006). Tasks that are challenging give students authority as they work, and overlap with student interests are more likely to promote intrinsic value for learning (Malone &

Lepper, 1987), which is closely related to mastery learning (Harackiewicz, Durik, Barron, Linnenbrink-Garcia, & Tauer, 2008). The invention tasks that were used in the Schwartz and Martin (2004) study were defined by some of these characteristics; specifically, they gave students control over attempts to solve challenging problems on their own. This could have affected the goals that students adopted while they were working on the invention activities. We adopt the preparation for future learning paradigm to investigate how different instructional activities interact with mastery-approach achievement goals and affect transfer. Next we describe the prior work on motivation related to students' achievement goals.

ACHIEVEMENT GOALS

Achievement goals are the self-reported reasons for how and why people engage in achievement situations (Elliot, 2005). They refer to the underlying aims a person has while engaging in an achievement-based activity, whether it is an academic setting, such as in-class assignments or test preparation, or not, such as sports or work activities. The model of achievement goals with the most empirical support is a 2 (mastery or performance) $\times$ 2 (approach or avoidance) framework, which results in four separable achievement goals: mastery-approach, mastery-avoidance, performance-approach, and performance-avoidance (Elliot & McGregor, 2001). These orientations guide the interpretation of events in the achievement environment and produce characteristic patterns of cognition, emotion, and behaviors (Kaplan & Maehr, 2007). This model has been validated across a number of studies (e.g., Elliot & McGregor, 2001; Elliot & Murayama, 2008) and widely used (e.g., Darnon & Butera, 2005; Finney, Pieper, & Barron, 2004). Because these goals are orthogonal they can be studied independently; for example, having a high orientation on one goal does not necessarily mean that one will have a low orientation on another. Typically, all of the goals are measured via self-report questionnaires, and the independent contribution of each is measured via statistical modeling.

These goals have been shown to be important predictors of student behaviors, emotions related to learning, and academic outcomes. For example, performance-avoidance goals have been found to be related to poor learning outcomes (Elliot & Church, 1997; Elliot, McGregor, & Gable, 1999) and to negative affective experiences, such as test anxiety (e.g., Elliot & McGregor, 1999) and reduced interest (Elliot & Harackiewicz, 1996). Performance-approach goals, in comparison, have been positively associated with achievement measures, such as grades in school settings (see Harackiewicz, Barron, Pintrich, Elliot, & Thrash, 2002; Linnenbrink-Garcia, Tyson, & Patall, 2008). However, they have also been associated with more superficial learning strategies (see Senko, Hulleman, & Harackiewicz, 2011, for a review) as well as negative behaviors, such as increased self-handicapping

(e.g., Midgley, Arunkumar, & Urdan, 1996) and decreased help seeking (e.g., Ryan, Gheen, & Midgley, 1998). Mastery-avoidance goals are a somewhat newer object of study, having been identified more recently than the other goals (Elliot, 1999; Elliot & McGregor, 2001). Thus, less evidence has accumulated about their associations with learning and affect.

In the current work we focus on mastery-approach goals. This is because these goals have shown the most promise for facilitating conceptual learning and transfer compared to the other achievement goals. Mastery-approach goals reflect students' aim to develop and acquire competence and understanding of a task or domain. They are typically measured by asking for one's degree of agreement with such statements as "In this class, it is important for me to understand the content as thoroughly as possible" (Elliot & McGregor, 2001). They have been associated with positive affective experiences, enjoyment, high self-efficacy, perceptions of competence, topic interest, better self-regulation and strategy use, and deeper processing of material (e.g., Elliot et al., 1999; Ford, Smith, Weissbein, Gully, & Salas, 1998; Harackiewicz et al., 2008; McGregor & Elliot, 2002; Pintrich, 1999; Somuncuoglu & Yildirim, 1999). In the face of failure, mastery-oriented students view the difficulty as a challenge and increase their effort and the complexity of strategies used (Elliott & Dweck, 1988).

Prior work has also shown that students who have mastery-approach goals tend to perform better on more complex tasks than on simple tasks (Graham & Golan, 1991; Jagacinski, Madden, & Reider, 2001). This prior work suggests that mastery-approach goals support deep conceptual processing and engagement, which may support transfer. However, there has been only limited empirical evidence for a direct link between mastery-approach goals and transfer (Pugh & Bergin, 2006). This tentative link has been observed on such measures as the transfer of a puzzle-solving strategy (Bereby-Meyer & Kaplan, 2005), transfer of helpful negotiation strategies (e.g., Gist & Stevens, 1998), and transfer from training to a complex naval radar tracking task (e.g., Ford et al., 1998). However, this effect has not been studied in strictly academic domains and settings or in a preparation for future learning framework. The current study directly addresses this issue.

It is important to note that we study mastery goals both as an individual difference variable as well as a state that is adopted during a learning activity. This follows the two main strands of research on achievement goals. One line of research, as described previously, assesses goals via questionnaires and treats them as semi-stable orientations (e.g., Wolters, 2004). The other attempts to experimentally manipulate goals, both in the laboratory (e.g., Elliott & Dweck, 1988) and in school settings (e.g., Elliot, Shell, Henry, & Maier, 2005), and treats them as dynamic and capable of rapid changes. In the current work we consider goals in ways that reflect both of these lines of research. That is, we view achievement goals both as semi-stable orientations that guide affect and cognition and as dynamic goal states that may change during the course of a given task. These

dynamic goals may influence behavior in concert with (or augment) existing orientations. To differentiate these ideas we refer to preexisting achievement goals as *mastery-approach orientation* and to a student's state during the learning activities as *mastery-related goal adoption*. Next we articulate the hypotheses for the role of existing mastery-approach orientation, the effect of instruction on mastery-related goal adoption, and how they interact to influence learning and transfer.

HYPOTHESES

The first research question we address focuses on how existing mastery-approach orientations impact learning and transfer. The research on the types of processing and cognitive strategies related to mastery-approach orientations suggests that these goals should facilitate deep understanding and knowledge transfer (Pugh & Bergin, 2006), even though this has only been weakly supported empirically (Graham & Golan, 1991; Jagacinski et al., 2001). This leads to our first hypothesis:

H1. Existing mastery-approach orientation will lead to better transfer.

We test this hypothesis by using logistic regression to examine the relationship between students' initial mastery-approach orientation and their likelihood of successfully solving the transfer problem.

The second research question we address is how different instructional activities influence goal adoption and learning behaviors. As described earlier, tasks that are open ended, grant students authority, and are challenging (i.e., invention activities) should lead to the adoption of mastery-related goals. In addition, based on prior research we expect that invention activities will lead to performance during learning that reflects deeper conceptual understanding. This leads to our second hypothesis:

H2. Invention activities will lead to more mastery-related goal adoption than tell-and-practice activities as well as more attention to important conceptual features of the learning problems.

We test this hypothesis by analyzing students' responses on an activity questionnaire that they filled out as they engaged in different learning activities to test for differences in participants' self-reported mastery-related goals. We also analyze students' problem-solving performance on the learning activities for evidence of attention to important conceptual features of the problems.

Finally, we expect to see an interaction between existing mastery-approach orientation and the type of instruction on transfer. We predict a moderating effect of invention activities on the effect of mastery-approach orientation. That is, we expect students who complete the tell-and-practice activities to transfer only to the

degree that their existing mastery-approach orientations promote constructive cognitive processes that lead to a deep understanding of the materials. Students lower in mastery-approach orientation who complete tell-and-practice activities will not be focused on developing an understanding of the materials and so may not use the same deep learning strategies as their high-mastery counterparts. In contrast, if the invention activities lead to more mastery-related goal adoption in the task, we would expect a smaller difference between the effect of higher and lower mastery-approach orientations on transfer for students who invent than for those who complete tell-and-practice instruction.

It is important to note that we do not expect the degree of goal adoption alone to be predictive of transfer, because adopting a goal does not necessarily mean that constructive cognitive processing will follow. We expect that goal orientations for an academic domain such as math, which develop over long periods of time, will be more predictive of the types of strategies and cognitive processes that a person will use than a goal adopted for one 15-min instructional activity. That is, even if a mastery goal is adopted for a given math task, a student who is not generally oriented toward developing his or her competence in math may not be equipped to use the most effective learning strategies possible, resulting in a less than perfect correlation between goal adoption and learning outcomes. However, we do expect a moderation effect, such that students who are lower in mastery-approach orientation who invent (and thus adopt more mastery-related goals) will be more likely to transfer than students with similar orientations in the tell-and-practice condition. This leads to our third hypothesis:

H3. There will be a moderation effect of invention activities on the beneficial effect of mastery-approach orientation for transfer, such that the effect of mastery-approach orientation will be a stronger predictor of the likelihood of transfer for the tell-and-practice activities than for invention.

We test this hypothesis by using logistic regression to examine the effect of existing mastery-approach orientation, the type of instruction, and the interaction between the two on the likelihood of a student successfully solving the transfer item.

METHODS

The materials and procedure in this study were modeled on the Schwartz and Martin (2004) work, though there are some important differences. One is that participants in our study worked individually rather than in groups. Another is that in their study all participants invented first and then were split into the experimental conditions. In our study the participants in the invention condition invented for both learning activity problems, whereas the participants in the tell-and-practice

condition practiced the methods they were shown throughout. This was done to better separate the motivational effects of invention from those of tell-and-practice activities. In addition, our study was conducted in only one laboratory session as opposed to multiple classroom sessions. Finally, the present study used college students, whereas Schwartz and Martin's used high school students.

Participants

A total of 104 undergraduates (M age = 18.5 years old, SD = 0.8 years, range = 18–22; 42% male, 45% female, 13% did not report their gender on the demographics sheet) from an Introduction to Psychology course at the University of Pittsburgh participated in return for course credit.

Design and Materials

We used a 2 (learning activity: invention vs. tell-and-practice) $\times$ 2 (learning resource: present vs. not), between-subjects, pre-/posttest design. Materials were presented as packets in binders. These packets contained, in order, an initial questionnaire, a pretest, a learning activity on variability, an activity questionnaire, an instructional video, a learning activity on standardization, a posttest, a final questionnaire, and a demographics sheet (see Figure 2).

Pretest materials. The pretest materials consisted of three items adapted from the Schwartz and Martin (2004) study. These assessed basic procedural ability, data representation skills, and a transfer item. Here we describe the transfer item because it is the focus of the current work (see Figure 3). This item gave participants two distributions—each one had a mean and a mean deviation given in the problem statement—and exceptional individual scores for each. The problem asked them to decide which score was more impressive, with directions to “use math to help back up your opinion.”

Learning materials. The learning materials consisted of a problem-solving activity on variability, a video explaining the mean deviation formula, and a problem-solving activity on standardization.

Variability activity. The variability problem asked participants to calculate which of four pitching machines was the most reliable, requiring students to consider how variable the data sets were. The same problem was presented to both the invention and tell-and-practice conditions (see Figure 4). The experimental manipulation was instantiated through different instructions and examples provided with the problem. Participants in the invention condition received instructions that stated the following:

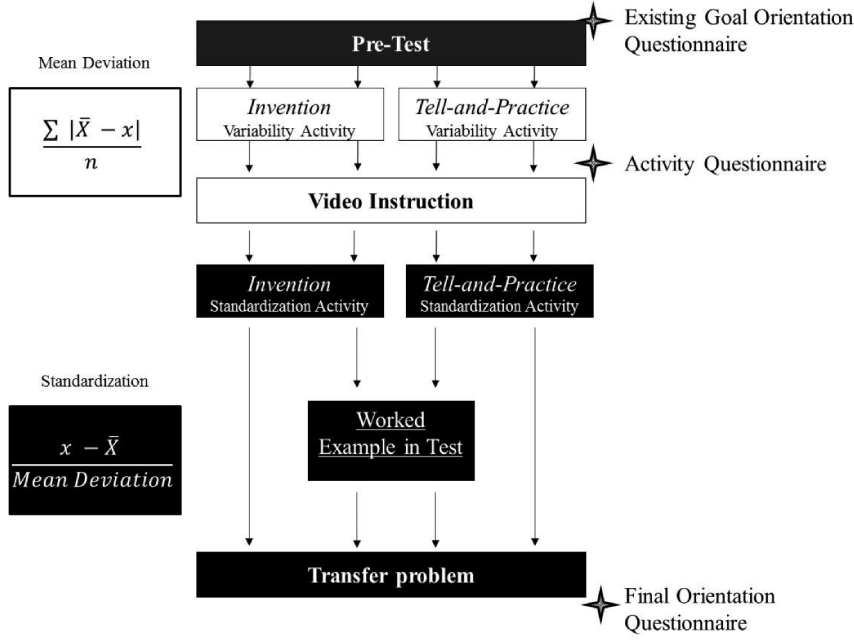


FIGURE 2 Chart representing the student activities during the experiment. From left to right, the down-arrows represent the path of the invention/no worked example, invention/ worked example, tell-and-practice/ worked example, and tell-and-practice/no worked example groups. The light boxes focus on mean deviation (shown at left), whereas the dark boxes, representing aspects of the pretest, learning activities, the worked example, and the transfer problem, focus on the concept of a standardized score (shown at left).

Driving Test

Susan and Robin are two teenagers who both just took their state driver's license road test. They are arguing about who got a better score on their test, which is scored out of 100 possible points. Susan got an 88 taking the driving test with Mr. Wheelie. The mean score Mr. Wheelie gave out that day was a 74, and the average deviation was 12 points. The average deviation indicates how close all the people taking the test were to the average. Robin earned an 82 on Mrs. Axel's driving test. On that day, the mean score Mrs. Axel gave out was a 76, and the average deviation was 4 points. Both Mr. Wheelie and Mrs. Axel tested one hundred teenagers that day. Who do you think did better, Susan or Robin? Use math to help back up your opinion.

FIGURE 3 One of two isomorphic transfer test items. Adapted from Schwartz and Martin (2004, p. 135).

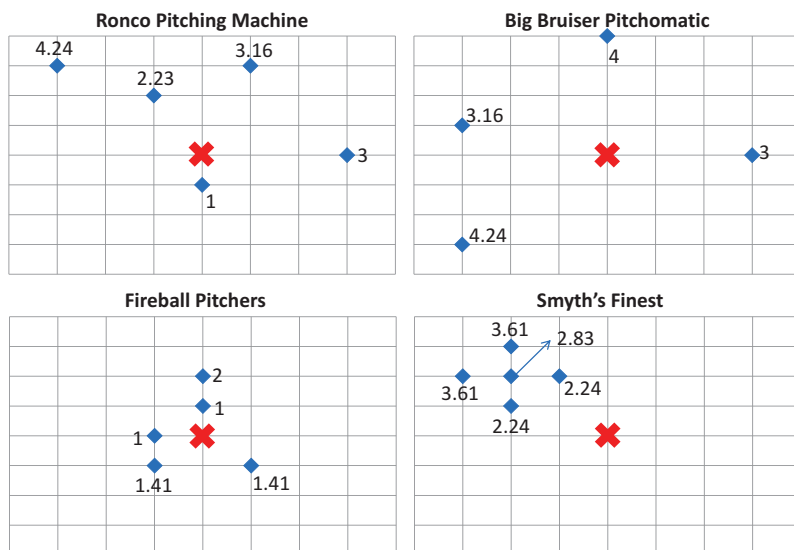


FIGURE 4 Image of the data sets given in the variability problem. Adapted from Schwartz and Martin (2004, p. 135) (color figure available online).

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.

They were given scrap paper and a calculator but no other resources. In the tell-and-practice condition the problem was preceded by a worked example. This worked example described how to compute mean deviation (see Figure 5). The instructions for the pitching machine problem told the students to “use the procedure shown before” in solving the problem.

Video instruction. An instructional video introduced the mean deviation formula and demonstrated its use in a worked example. The video then gave two simple practice problems that students completed on their own, each of which was followed by a walkthrough of the solution steps. Students in both instructional conditions watched the same video and completed the same practice problems.

Standardization activity. The standardization problem required students to decide which of two world records was “more shattered,” requiring students to compare individual scores from two different sample distributions (see Figure 6).

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
26
27
27
28
29
36
45
47
47
48

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 $26 + 27 + 27 + 28 + \dots + 48$, which equals 360. We then divide by 10, since there are 10 values in the data set. This gives us a mean of 36.

x	Mean - x
26	10
27	9
27	9
28	8
29	7
36	0
45	9
47	11
47	11
48	12

To calculate the variability, you need to calculate how far each variable 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 ($10 + 9 + 9 + \dots + 12$) 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.

FIGURE 5 The worked example given to the tell-and-practice group before attempting the learning activity on mean deviation.

Top High Jumps in 2000	
Height	Number of Jumps
6'6"	1
6'8"	2
6'10"	3
7'0"	5
7'2"	6
7'4"	7
7'6"	4
7'8"	1

Top Long Jumps in 2000	
Height	Number of Jumps
21'6"	1
22'0"	2
22'6"	2
23'0"	9
23'6"	9
24'6"	4
25'0"	1
25'6"	1

FIGURE 6 Data given as part of the standardization activity. Adapted from Schwartz and Martin (2004, p. 176).

Both types of activities included the exact same problem statement but had different concluding instructions. The instructions for the participants in the invention condition were to “write down the procedure you use and the value you compute for each record using the data below.”

It is critical to note that those in the invention condition were not shown any procedure or equation for how to do this. In contrast, the participants in the tell-and-practice condition were first given a separate example that illustrated how to graphically arrive at a solution for a different problem dealing with classroom performance (see Figure 7). This came before the standardization activity, which dealt with athletic records (see Figure 6). Just as in the variability activity, the participants given tell-and-practice instructions were told to “use the procedure shown before” in solving the problem.

Posttest materials. The test consisted of a variety of test items that were adapted from Schwartz and Martin’s (2004) study. These items assessed the ability to use the standard deviation formula, represent data visually, and reason about data. As with the pretest, the critical item for our hypotheses was the transfer item (see Figure 3). This problem asked students to decide which score or value from two different distributions was better given the descriptive statistics for each distribution. The transfer item was isomorphic to the pretest problem but a different specific problem (different values and a different cover story). Two isomorphic versions of this problem were used on the pre- and posttests, and the order of their presentation was counterbalanced across participants.

Embedded resource. The other experimental factor, the learning resource, was manipulated by the presence or absence of a worked example in the posttest.

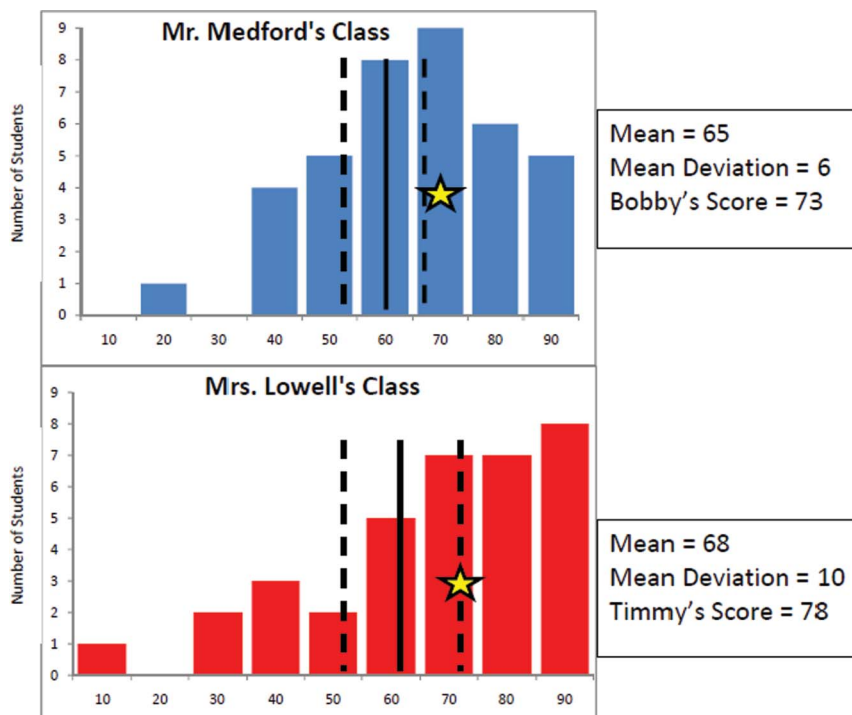


FIGURE 7 Image included with example and instructions given to tell-and-practice students before the standardization activity. Adapted from Schwartz and Martin (2004, p. 177) (color figure available online).

This worked example showed how to calculate a standardized score on one simple data set and then gave another simple problem and asked participants to solve it using standardized scores (see Figure 8). Participants were randomly assigned packets, half of which included this worked example (represented by the inside arrows of Figure 2) and half of which did not (represented by the outside arrows of Figure 2). In packets containing the embedded resource, the transfer question always appeared at least two problems after the worked example. If participants noticed the applicability of the worked example to the transfer problem this was not because of simple temporal proximity, as at least 10 min had passed, during which other types of problems had been considered.

Motivational measures. Existing achievement orientations were assessed using the 12-item validated Achievement Goal Questionnaire (Elliot & McGregor, 2001), which had three items for each of the four constructs (mastery-approach,

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

Diver	High Dive	Low Dive
Cheryl	8.3	6.4
Julie	6.3	7.9
Celina	5.8	8.8
Rose	9	5.1
Sarah	7.2	4.3
Jessica	2.5	2.2
Eva	9.6	9.6
Lisa	8	6.1
Teniqua	7.1	5.3
Aisha	3.2	3.4

FIGURE 8 The first portion of the learning resource on standardization. Adapted from Schwartz and Martin (2004, pp. 177–178).

mastery-avoidance, performance-approach, performance-avoidance; see Table 1 for the mastery-approach items). Though a revised version has recently been developed (Elliot & Murayama, 2008), the most significant revisions were on avoidance items, not the mastery-approach items that are the focus of this work. Each item consisted of a statement about one's goals in math classes, and participants were asked to rate the degree to which they agreed or disagreed with the statement on a 7-point Likert scale (1 = *strongly disagree*, 4 = *unsure*, 7 = *strongly agree*). This measure was adapted to be about goals in math classes rather than a global assessment about academics (see Table 1). Two forms were created with all 12 items in a randomized order; one was administered at the beginning of the experiment and one at the end. Cronbach's alpha was calculated to measure the reliability for the achievement goal constructs on the Achievement Goal Questionnaire. Cronbach's alpha values greater than .8 are considered to indicate good reliability, especially with only three

TABLE 1
Mastery-Approach Items on the Initial Motivation Questionnaire

In math classes, I want to learn as much as possible.
In math classes, it is important for me to understand the content as thoroughly as possible.
In math classes, I desire to completely master the material presented.

Note. Adapted from Elliot and McGregor (2001, p. 504).

items for each construct, and values greater than .7 are considered to indicate adequate reliability (Cortina, 1993). On the initial questionnaire the mastery-approach and performance-approach items had good consistency (α s = .86 and .92, respectively), and the mastery-avoidance and performance-avoidance constructs approached adequate consistency (α s = .68 and .68, respectively). The three items for each achievement goal were then summed to form a construct score.

We also developed a short questionnaire to measure participants' goals during the initial learning activity. These items were designed to mirror certain aspects of mastery goal orientations and were rated on a 5-point Likert scale (1 = *strongly disagree*, 3 = *unsure*, 5 = *strongly agree*). Although achievement orientations are considered stable, it is likely that specific goals are adopted within any given learning opportunity. The goal adoption within a particular task can be considered an "instantiated" achievement goal, which is what we aimed to capture with this activity questionnaire. This follows prior research, which has shown that task demands mediate the effect of achievement orientations on how people engage in a task (Elliot & Harackiewicz, 1996). Less is known, however, about how task demands influence which goals are subsequently adopted. To our knowledge this represents a novel methodology for attempting to triangulate the interacting effects of instruction and motivation. Although this is only a first attempt at constructing such a measure, we believe it can aid in helping disentangle the effect of existing achievement goal orientations and task-related goal adoption. The four items reflecting mastery goal adoption had adequate reliability (α = .71; see Table 2). The four items measuring different affective experiences such as challenge and frustration were also included but are omitted from these analyses as they were exploratory and did not have adequate reliability (α = .13).

Procedure

Students were run individually in one laboratory session. The procedure consisted of an initial Achievement Goal Questionnaire, followed by the pretest, the variability activity, the activity questionnaire, a video, the standardization activity, a posttest, a final Achievement Goal Questionnaire, and a demographics sheet (see Figure 2 for a visual representation). Participants took as long as they needed to

TABLE 2
Items on the Activity Questionnaire

Goals
I was concerned with the quality of the procedure I was using.
I was concerned with how well I understood the procedure I was using.
I tried to understand why the procedure I was using worked.
I was concerned that the procedure I was using was not correct.

complete the questionnaires, with no one taking longer than 3 min. The pretest took 5 min per problem, for a total of 15 min. The two learning activities and the video took 15 min each, for a total of 45 min. Each problem in the posttest took 5 min, for a total of 35 min for participants given the worked example and 30 min for participants without the worked example. In total the experiment took approximately 2 hr to complete.

RESULTS

We predicted that existing mastery-approach orientations, as measured by the initial questionnaire, would facilitate transfer, as defined by solving the transfer problem (H1). In addition, we predicted that invention activities would lead to better reasoning on the learning activities and facilitate mastery-related goal adoption during the learning task compared to tell-and-practice activities (H2). We also expected an interaction, such that participants high in mastery-approach orientation would transfer, regardless of the type of instruction, whereas those low in mastery-approach orientation would benefit from invention activities relative to tell-and-practice (H3). This expectation was derived from the hypothesis that invention activities would facilitate mastery-approach goal adoption, whereas the tell-and-practice activities would not, and that this would benefit students lower in mastery-approach orientation in particular.

We begin by examining the effect of our manipulations on transfer, followed by a series of analyses presented in order of the hypotheses. First, we examine the effect of existing mastery-approach orientation on transfer performance. Second, we present the results of performance on the learning activities as well as the results from the activity questionnaire to examine the effect of invention activities on mastery-related goal adoption. Finally, we present evidence for the interaction of existing mastery-approach orientation and type of instruction. For all analyses alpha was set to .05 (Keppel, 1991). We report effect sizes of Cohen's *d* where appropriate. Effect sizes are 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).

Learning Manipulations and Transfer

The transfer item gave students the mean and mean deviation for two distributions, and an exceptional score from each (e.g., a score on a test from two different teachers), and asked the students to decide which score was more impressive. Although similar to the second learning activity, this problem only provided the students with the descriptive statistics rather than the raw data. The transfer item was scored dichotomously as correct or incorrect. A correct response successfully computed a standardized score or correctly used a graphical representation of the deviation and used that to solve the problem. All other answers were scored as incorrect. Two raters coded 40% of these problems and had perfect agreement, so the remaining data were coded by the primary rater. Because this response was scored dichotomously, logistic regressions are used for the analyses, with transfer as the dependent measure. Logistic regressions express the (logarithmically transformed) odds of a dependent outcome occurring—in this case, successful transfer (Tabachnik & Fidell, 2007). Put simply, in these analyses the results of the logistic regressions inform us whether the probability of a person successfully solving the transfer problem changes as a function of the independent variables included in the analysis. One benefit of such an approach is that it can model both continuous as well as categorical independent variables. Thus, we can use both our categorical, dummy-coded experimental variables and our continuous orientation scores as predictors in the various models we test, as well as their interactions.

Only 5 of the 104 (5%) participants had a correct answer on the transfer pretest. Posttest results reported here include all participants, even those who answered correctly on the pretest. For all analyses the pattern of results is the same if we exclude those participants who scored at ceiling on the pretest.

A binary logistic regression was conducted to analyze the effect of our manipulations, as well as their interactions, on transfer. A dummy variable was created for each manipulation so that the presence or absence of a worked example in the test was dummy coded, as was whether the student completed an invention or tell-and-practice learning activity. A term representing the Worked Example $\times$ Learning Activity interaction was also created (Jaccard, 2001; see Appendix A for the mathematical model).

A test of the overall model compared to a constant-only model was significant, $\chi^2(3, N = 104) = 20.18, p < .05$. It correctly predicted classification in 71% of the cases. Within the model only the coefficients for the worked example variable, $B = 2.33$, $Exp(B) = 10.29$, Wald's $\chi^2(1, N = 104) = 7.8, p < .05$; and the constant, $B = -2.49$, $Exp(B) = 0.08$, Wald's $\chi^2(1, N = 104) = 11.40, p < .05$, were significant (see Table 3). $Exp(B)$ refers to the value obtained when the coefficient is entered into the exponential function, e^x , which is equal to the change in odds predicted by a unit change in the coefficient (Jaccard, 2001). For the worked example variable this value indicates that those students who received the worked example

TABLE 3
Logistic Coefficients and Odds Ratios for Terms in the Logistic Regression Predicting
Transfer From Learning Activity and the Presence of a Worked Example

<i>Predictor</i>	<i>Logistic Coefficient</i>	<i>Odds Ratio</i>	<i>p</i>
Learning Activity	−0.78	2.18	.39
Worked Example	2.33	10.29	.005*
Learning Activity × Worked Example	−0.47	0.62	.66
Intercept	−2.49		.001*

* $p < .05$.

were 10 times more likely to transfer than those who did not. Neither the learning activity variable nor the variable representing the interaction between the worked example and learning activity were significant predictors. Among those who did not receive a worked example, only 6 of 52 (11%) solved the problem correctly; however, among those who received a worked example, 26 of 52 (50%) correctly solved the problem. This reflects that among those who received the worked example, 14 of 26 invention students and 12 of 26 tell-and-practice students solved the transfer problem correctly. This pattern of results shows that both of the learning activities seemed to prepare students for future learning from the worked example, which is different than the findings in Schwartz and Martin (2004), which showed that the invention condition performed best. Potential reasons for this difference are discussed later in relation to results on motivation and transfer.

Testing H1: Mastery-Approach and Transfer

The first hypothesis predicted that existing mastery-approach orientation would lead to better transfer and that the other orientations would not. A binary logistic regression was conducted with all of the initial goal orientation scores—mastery-approach, mastery-avoidance, performance-approach, and performance-avoidance—entered as predictors of transfer (see Appendix B). These values were measured by student responses on the Achievement Goal Questionnaire administered at the beginning of the experiment and were centered around their means to aid in interpretation (Jaccard, 2001). As it was clear from the first analysis that students needed a worked example to successfully transfer, we restricted our sample to just those students who received the worked example.

A test of this model compared to a constant-only model was significant, $\chi^2(4, N = 52) = 12.40, p < .05$.² The model successfully predicted with 71% accuracy,

²This analysis was also conducted on the entire sample, including students who did not receive a worked example. Although the overall model was not significant, the pattern of results was the same, with the coefficient for the mastery-approach term being significantly different from zero, while the other coefficients were not.

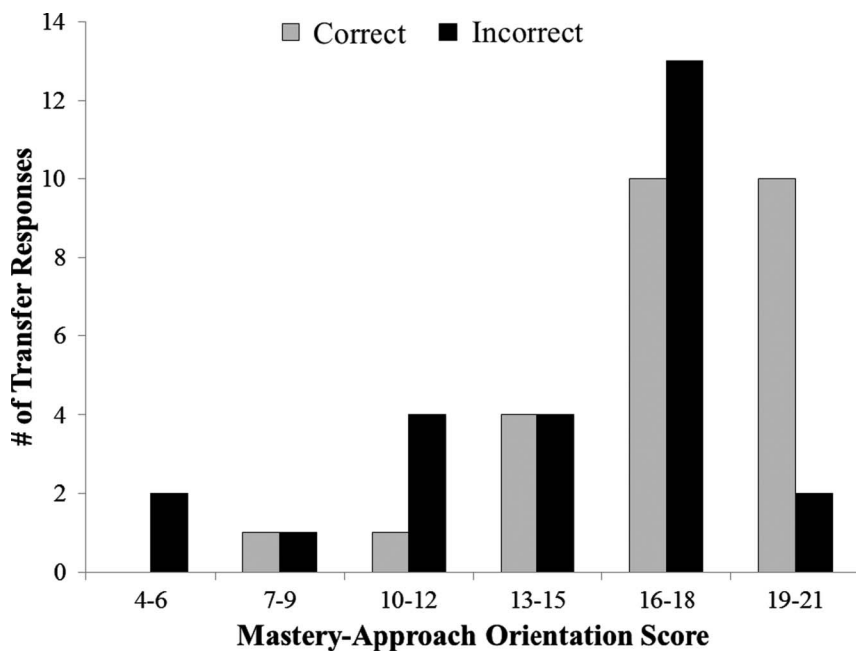


FIGURE 9 The number of correct and incorrect transfer responses for different mastery-approach orientations.

better than the 50% that would be expected based solely on the data. In this model only the mastery-approach term was significant, $B = 0.37$, $Exp(B) = 1.45$, Wald's $\chi^2(1, N = 52) = 7.44$, $p < .05$. This indicates that for every unit increase in mastery-approach score, the predicted odds of a student successfully transferring became 45% higher (see Figure 9 for a representation of transfer responses as a function of mastery-approach orientation). Every unit change in each of the other orientations did not affect the likelihood of transfer; it is critical to note that none of the other achievement goal orientations significantly predicted transfer.

Testing H2: Instruction, Learning, and Goal Adoption

The second hypothesis predicted that invention activities would lead to a greater focus on conceptual features of the learning activities and increase mastery goal adoption while engaging in the learning packet. These are examined by analyzing student performance on the learning activities and their responses on the goal questionnaire.

Learning performance. Performance on the learning activities was scored using a coding rubric adapted from Schwartz and Martin (2004) with three categories: an incorrect response (0), a partially correct response (1), or a conceptually correct response (2). For the variability activity, participants were asked to decide which pitching machine was the most reliable using a sound mathematical metric. An incorrect response was coded as a 0, a response that only focused on the mean distances (the data given) and not the deviation values was coded as a 1, and a response that reflected mean deviation was coded as a 2.

For the standardization activity students were asked to decide which of two records was more impressive given the distribution each came from. No participants came up with the correct quantitative solution (which would have required using a formula to calculate standardized scores). However, attempts that reflected a comparison of each individual score to the distribution it came from as well as a comparison of the relative performance of the two exceptional scores were coded as a conceptually correct response, whether done numerically or graphically, and received a score of 2. A score of 1 was given if the attempt to solve the problem only reflected the variability within each data set. The critical difference between a score of 1 and a score of 2 was an explicit comparison of each score to its own distribution's variability. A score of 0 was given for all other attempts that did not reflect the variability of the data sets. Coding was done by two raters for 25% of the data. The coding reliability was high for each learning activity ($\kappa > .80$). Disagreements were resolved via discussion, and the rubric was revised accordingly. The remaining data were coded by the primary rater.

For the variability activity, participants given tell-and-practice activities ($M = 1.85$, $SD = 0.36$) performed much better than participants given invention activities ($M = 0.94$, $SD = 0.46$), $t(102) = 11.01$, $p < .05$, $d = 2.18$. This is not surprising, as they were shown the mean deviation procedure to use in the learning example that accompanied that problem (see Figure 4), showing proper use of the demonstrated formula. However, on the second learning activity, which dealt with standardization, students in the invention condition produced better attempts ($M = 1.15$, $SD = 0.78$) than those in the tell-and-practice condition ($M = 0.69$, $SD = 0.75$), $t(102) = 3.07$, $p < .05$, $d = 0.61$. The participants given invention activities were more likely to represent the idea of variability in their attempts to solve the problem than the participants given tell-and-practice activities, even though the tell-and-practice instructions showed participants how to represent variability using a graphing procedure. This result provides some evidence that the participants in the invention condition acquired a deeper understanding of the concept of variability than the participants given tell-and-practice.

Activity questionnaire. The second part of H2 predicted that invention would lead to more mastery-related goal adoption in the learning activities. To test

this, it was important to ensure that the experimental groups were equivalent in their initial achievement goal orientations. There were no significant differences between the invention and tell-and-practice conditions on their initial mastery-approach orientation score, $t(102) = 0.84$, *ns*. Similarly, there were no differences on the other constructs on the initial questionnaire, nor were there any differences on the same questionnaire given at posttest, all $ts(102) < 1.11$, *ns*. These results show that the groups had similar goal orientations upon entering and exiting the experiment, and therefore any differences on the activity questionnaire are likely due to task-related goal adoption as a result of the instructional manipulation.

Immediately after the variability activity an activity questionnaire was administered. This questionnaire asked students about their mastery-related goals in the learning activity they had just completed. Differences between the experimental groups were observed in the responses to three of the four items on this questionnaire (see Table 4). These differences, taken together with the fact that we did not find a difference on mastery-approach or any of the other orientations on the initial or final Achievement Goal Questionnaires, supports the claim that the activity questionnaire was measuring goal adoption in the task as opposed to measuring general orientations.

Participants in the invention condition were more likely to be concerned with the quality of the procedure they were using, $t(102) = 2.82$, $p < .05$, $d = 0.56$; as well as their level of understanding of the procedure, $t(102) = 2.75$, $p < .05$, $d = 0.54$. Together, these items provide evidence that the participants who were given invention activities were more likely to endorse mastery-related goal items than those given tell-and-practice activities. Participants given invention activities were also more likely to be concerned with whether their procedure was correct, $t(102) = 4.02$, $p < .05$, $d = 0.80$. This could be because the participants given tell-and-practice activities had no reason to doubt the validity of the example procedure, so they did not feel any concern over it. Another possibility is that

TABLE 4
Mean (SD) Response Scores on the Activity Questionnaire

Item	Invention	Tell-and-Practice
I was concerned with the quality of the procedure I was using.*	3.71 (0.98)	3.15 (1.04)
I was concerned with how well I understood the procedure I was using.*	3.83 (1.10)	3.23 (1.11)
I tried to understand why the procedure I was using worked.	3.58 (0.96)	3.27 (1.14)
I was concerned that the procedure I was using was not correct.*	3.92 (1.15)	2.96 (1.28)

* $p < .05$.

the open-ended nature of the invention activities increased the participants' self-monitoring of whether the procedure they were using was helping to solve the problem.

Testing H3: Mastery-Approach and Instruction Interaction

Our third hypothesis predicted that invention activities would moderate the effect of existing mastery-approach orientation on transfer. Given that the prediction that invention activities lead to more mastery-related goal adoption was supported, we had reason to examine the prediction that those lower in mastery-approach orientation would be more likely to transfer from invention than from tell-and-practice. To evaluate this prediction we conducted a binary logistic regression that included the mastery-approach orientation score, a dummy-coded variable for the learning activity, and the interaction term (see Appendix C). As in the earlier analyses, we limited this analysis to only those students who received the worked example, who might reasonably have been expected to transfer.

A test of this model compared to a constant-only model was significant, $\chi^2(3, N = 52) = 19.72, p < .05$. This model correctly predicted with 71% accuracy. The coefficient for the constant term was marginally significant, $B = -1.79$, $Exp(B) = 0.17$, Wald's $\chi^2(1, N = 52) = 3.03, p = .08$. In addition, the coefficient for the learning activity dummy variable was marginally significant, $B = 1.94$, $Exp(B) = 6.98$, Wald's $\chi^2(1, N = 52) = 3.10, p = .08$. This result indicates a trend that, relative to the students who received tell-and-practice activities and holding mastery-approach orientation constant, students who received invention activities were more likely to transfer. The coefficient for the mastery-approach orientation score was significant, $B = 1.59$, $Exp(B) = 4.88$, Wald's $\chi^2(1, N = 52) = 5.09, p < .05$, indicating that for participants in the tell-and-practice condition (the reference group in the regression model), each unit change in mastery-approach orientation changed the odds by a factor of 4.8 (see Table 5). Of critical note is that the coefficient for the interaction term was also significant, $B = -1.50$, $Exp(B) = 4.88$, Wald's $\chi^2(1, N = 52) = 4.45, p < .05$, indicating that the effect of mastery-approach orientation was different for the invention and tell-and-practice groups. For participants in the invention condition, each unit change in mastery-approach orientation resulted in the odds changing by a factor of only 1.09 (see Figure 10a). For those who invented, it is clear that the relationship with mastery-approach goals was less important, as every unit increase in mastery-approach goals only increased the odds of successfully transferring by 9%. However, among those who completed tell-and-practice activities, a different pattern emerged. For every unit increase in mastery-approach goals, the odds were multiplied by almost 5. This leads to a pattern such that those tell-and-practice students who were higher in mastery-approach goals were very likely to successfully transfer, whereas those who were lower in those goals were unlikely to do so (see Figure 10b).

TABLE 5
Logistic Coefficients for the Interaction Between Learning Activity and Mastery-Approach Orientation

<i>Predictor</i>	<i>Logistic Coefficient</i>	<i>Odds Ratio</i>	<i>p</i>
Learning Activity	1.94	6.98	.08 [†]
Mastery-Approach Orientation	1.59	4.80	.02*
Learning Activity × Mastery-Approach Orientation	−1.50	0.22	.04*
Intercept	−1.79		.08 [†]

[†] $p < .10$. * $p < .05$.

In sum, the mastery-approach orientation of tell-and-practice participants played a large role in determining the likelihood that they transferred successfully. However, the initial mastery-approach orientation of participants who invented had a much smaller role in determining the likelihood of transfer. Students who completed invention activities generally transferred with about the same likelihood, regardless of mastery-approach orientation.

DISCUSSION

As expected, we found evidence that more endorsement of a mastery-approach orientation predicted better transfer (H1). We found evidence for this prediction in the logistic regression equation showing that this variable accounted for significant variance in predicting the likelihood of correctly solving the transfer problem. Among those who received a worked example, every unit increase in mastery-approach orientation on the Achievement Goal Questionnaire increased the odds of successfully transferring 45%. None of the other orientations were predictive of transfer, indicating the unique contribution of the mastery-approach achievement goal.

We also predicted that invention activities would lead to more focus on the conceptual features of the learning activities as well as more mastery-related goal adoption in the learning activities (H2). This was supported by the results of the learning performance, as well as a questionnaire administered after the first learning activity. Specifically, the invention group attempted to use more sophisticated conceptions of variability in the standardization activity. In addition, those participants who were given the invention activities were more concerned about the quality of their problem-solving approach and how well they understood that approach compared to the participants given the tell-and-practice activities. Prior work has shown that the structure of learning environments can influence student goal adoption (Ames, 1992; Ames & Archer, 1988). The current study found a

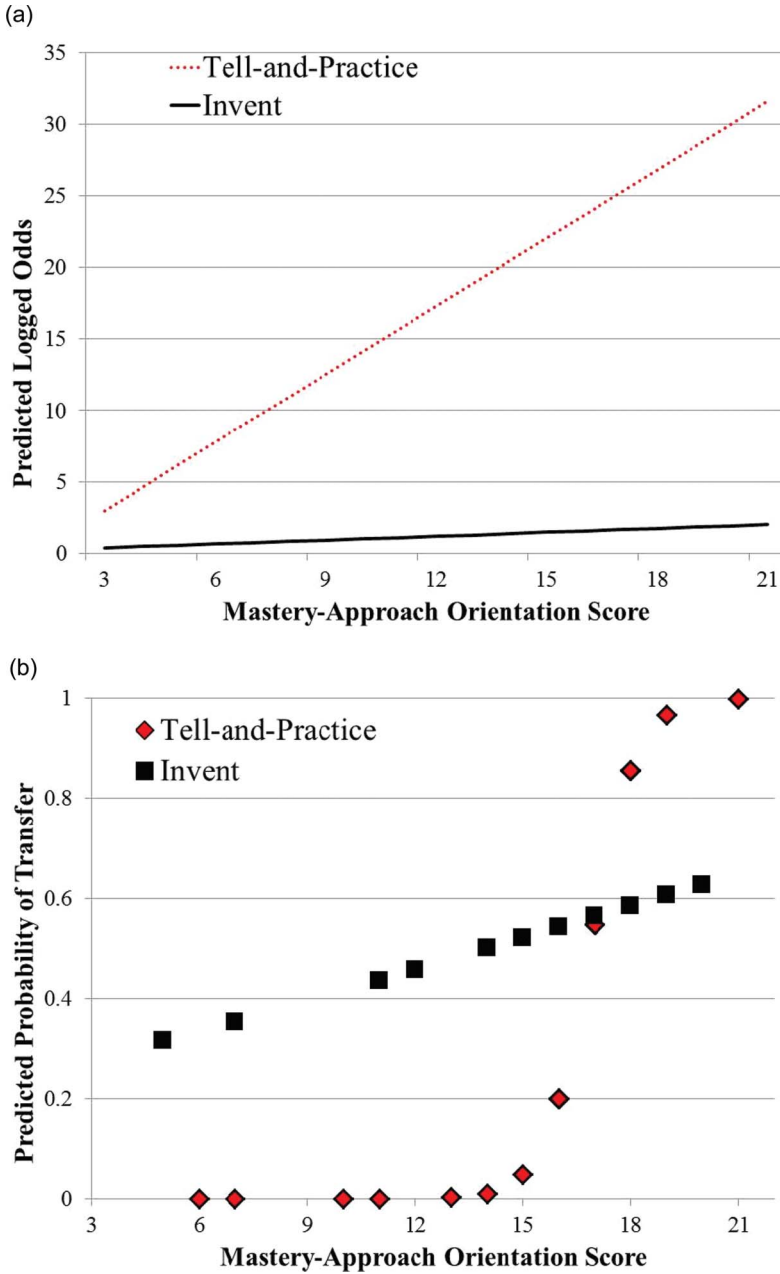


FIGURE 10 (a) The predicted logged odds of transfer as a function of mastery-approach orientation, for each learning activity. (b) The predicted probability of transfer for the range of mastery-approach orientation on the initial questionnaire, for each learning activity (color figure available online).

similar effect with a much shorter instructional intervention. The structure of an individual 15-min instructional event can affect goal adoption for the task.

Finally, we had predicted that the benefit of mastery-approach orientation would be moderated by invention activities, as these would produce some level of mastery-related goals in the students as well (H3). This prediction was supported. Participants who entered the experiment very high in mastery-approach orientation were likely to transfer regardless of the type of instruction. However, at lower mastery-approach orientations a large difference was apparent between participants given invention activities and those given tell-and-practice activities. Specifically, those lower in mastery-approach orientation given tell-and-practice activities were much less likely to transfer than those given invention activities (see Figure 10b).

At first glance our findings appear to contrast with the results of Schwartz and Martin (2004). Specifically, they found an interaction such that only those students who completed invention activities and received a worked example demonstrated transfer, whereas in our experiment we found a main effect of worked example only. We believe this difference may be due to the different samples and measures used in the two studies as well as differences in the methodology. In terms of the methodologies used, Schwartz and Martin conducted their research in classrooms over a longer instructional period, and they had their participants work in groups. Invention activities may be particularly beneficial when individuals can discuss their ideas with peers over an extended period of time, although they do appear to have observable effects on motivation and learning in a short instructional session.

Our sample was drawn from university students as opposed to ninth-grade high school students, so we might expect those students who have advanced to college to be more mastery-approach oriented than typical high school students. Therefore, the effect of existing mastery-approach orientation aiding transfer may be more clearly visible in our sample, boosting the performance of our tell-and-practice condition relative to Schwartz and Martin's (2004). Note that in our tell-and-practice condition mastery-approach orientation had a large effect on whether students transfer successfully or not. We do not know whether the participants in Schwartz and Martin's study had similar or different mastery-approach orientations compared to our participants because achievement goal orientations were not measured in their study.

Together these findings show that invention activities facilitate mastery-approach goal adoption in participants while they engage in that learning environment as well as lead them to produce more conceptually advanced attempts to complete the standardization activity. These attempts may have been a result of mastery goals being adopted in this type of a learning environment or of students engaging in an open-ended task that asked for the generation of a novel solution. In contrast, tell-and-practice participants may have become so focused on replicating the procedure that they did not pay attention to the conceptual features of the example and the problem and, with this procedural focus, missed the

critical concept of variability within each distribution. Goals adopted in the task may have persisted past the learning phase, affecting the types of strategies participants used to study the worked example. Or it is possible that the goal orientations impacted *both* what was learned from the standardization activity as well as what was learned from the worked example. Future work should provide a fine-grained analysis of exactly how motivation orientations and goals impact the underlying cognitive processes during the initial and subsequent learning activities.

CONCLUSIONS

The current work provides a demonstration that student motivation can have a large impact on knowledge transfer. Specifically, students' achievement goal orientations toward math—the reasons why they engage in and how they view achievement activities in that domain—had implications for whether they transferred their knowledge. We observed that students who were initially high in mastery-approach orientation were likely to transfer in a test of preparation for future learning regardless of what type of learning activity they were given. This result suggests that mastery-approach goals may serve as a mechanism of transfer that facilitates constructive cognitive processes and helps connect later learning episodes with relevant earlier learning. This is empirical evidence that students' motivations can lead to different learning outcomes, an important first step in developing a theory for how motivation can influence and interact with cognition.

In addition to highlighting the importance of understanding how existing goal orientations toward a domain are related to transfer this work explores how those motivational orientations may interact with instruction. We showed that particular learning activities may trigger the adoption of specific goals within the instruction, and these goals may impact which features become the focus of attention (i.e., invention triggers both mastery-related goals and the use of conceptually deep features) as well as how one approaches future tasks. For those who entered the activity initially low in mastery-approach orientation, there was a particular benefit in learning with invention activities on transfer. This result shows that particular educational tasks can facilitate goal adoption and transfer for some students. Future work should further investigate this interaction and examine the robustness of the effects in terms of how long such effects last as well as to what domains they can be extended. For example, what steps need to be taken to turn adopted goals into more stable orientations? In addition, we have examined goal adoption using a short, self-report questionnaire. Research that focuses specifically on developing reliable and valid measures of goal adoption within a task will be important. This work could combine students' self-reports, behavioral observation, and possibly even physiological signals to form a more complete assessment tool.

Considering the role of motivational constructs may provide a new way to bridge research on situative perspectives on learning and transfer that value the aspects of the social situation to more classic notions of transfer mechanisms, such as analogy, rules, and schemas. Achievement goals have been shown to be related to not only the features of the instruction but also aspects of the social situation such as whether the learning situation is perceived competitively or collaboratively (Darnon, Butera, & Harackiewicz, 2007; Darnon, Muller, Schrager, Pannuzzo, & Butera, 2006) as well as other aspects of the situation typically out of the purview of the classic approach of studying transfer, such as perceived competence and difficulty (e.g., Darnon, Butera, Mugny, Quiamzade, & Hulleman, 2009; Elliot & Church, 1997), type of feedback received (e.g., Butler, 1987), and social comparisons (e.g., Darnon, Dompnier, Gilliéron, & Butera, 2010). Thus, motivational constructs may serve as a link to bridge concepts and features of the situative perspective to cognitive processes and other constructs such as arousal and affect, which may also play a (yet unknown) role in knowledge transfer. The current study is a first step in examining such relationships, and future work should explore how other motivational constructs, such as self-efficacy, arousal, affect, engagement, and identity, impact learning and transfer.

This work has also begun to map out a possible explanation for an unresolved aspect of the achievement goal literature. Reviews have shown that many studies fail to find an effect for mastery-approach goals on measures of achievement in classroom settings (e.g., Harackiewicz et al., 2002; Linnenbrink-Garcia et al., 2008). We hypothesize that this result may have to do with the measures themselves. If typical measures of grades are multiple-choice tests that emphasize replicative and applicative knowledge, then one would not expect to see effects of mastery-approach goals (Barron & Harackiewicz, 2001; Harackiewicz et al., 2008). That is, measuring achievement based on grades in college classrooms may bias the results toward not finding effects for mastery-approach because grades may not capture interpretive knowledge. Similarly, studies that show a relationship between performance-approach goals and achievement may be using learning measures that reflect shallow learning (see Harackiewicz et al., 2002). These goals have been associated with rehearsal and more superficial cognitive strategies that may improve performance on skill-based or replicative knowledge tests.

Prior work has shown that there already is some evidence for this link, in that performance-approach goals predict performance on simpler tasks, whereas mastery-approach goals predict performance on more complex tasks (see Linnenbrink-Garcia et al., 2008; Utman, 1997, for reviews). Future work should look into whether the assessment distinction applies in classrooms. For example, perhaps separate effects of mastery-approach and performance-approach orientations on test grades may be found if the focus is directed to particular types of measures. A study that uses multiple types of assessments might be able to address this question by having a variety of levels of difficulty for various multiple-choice

items, or by having both multiple-choice and essay questions on the same assessment (see Belenky, Nokes, & Bernacki, 2011). We would predict differences in achievement goals to be evident in different types of assessments. In this view, mastery-approach orientations would be associated with performance on more conceptual, open-ended, and application-based questions, whereas performance-approach orientations would be associated with performance on more factual, procedural, and recall-based questions (see Senko et al., 2011, for a formalization of this “depth-of-learning hypothesis”).

It is clear that much work remains to be done in linking research on motivational constructs, such as achievement goals, with specific cognitive processes and outcomes (see Nokes & Belenky, 2011). However, we believe it is a worthwhile enterprise that will yield many benefits, contributing to a theoretical understanding of how people learn and transfer as well as helping to improve educational interventions to facilitate such learning.

ACKNOWLEDGMENTS

This research was supported by Grant SBE00354420 from the National Science Foundation to the Pittsburgh Science of Learning Center (<http://www.learnlab.org>). We thank research assistants Kara Cohen and Stephen Grivnow for their help in coding the data. We would also like to thank Daniel Schwartz for his help with the development of the materials. We gratefully acknowledge Christian Schunn and Kevin Crowley for their insightful feedback on this work, as well as Joanne Lobato and four anonymous reviewers for their very helpful suggestions and comments on the article.

REFERENCES

- Ames, C. (1992). Classrooms: Goals, structures, and student motivations. *Journal of Educational Psychology, 84*, 261–271.
- Ames, C., & Archer, J. (1988). Achievement goals in the classroom: Students' learning strategies and motivation processes. *Journal of Educational Psychology, 80*, 260–267.
- Barnett, S. M., & Ceci, S. J. (2002). When and where do we apply what we learn? A taxonomy for far transfer. *Psychological Bulletin, 128*, 612–637.
- Barron, K. E., & Harackiewicz, J. M. (2001). Achievement goals and optimal motivation: Testing multiple goal models. *Journal of Personality and Social Psychology, 80*, 706–722.
- Belenky, D. M., Nokes, T. J., & Bernacki, M. L. (2011, August). *Achievement goals over time: How changes in mastery and performance-approach predict deep knowledge*. Paper presented at the 14th Biennial Conference of the European Association for Research on Learning and Instruction, Exeter, UK.
- Bereby-Meyer, Y., & Kaplan, A. (2005). Motivational influences on transfer of problem-solving strategies. *Contemporary Educational Psychology, 30*, 1–22.

- Bransford, J. D., Franks, J. J., Vye, N. J., & Sherwood, R. D. (1989). New approaches to instruction: Because wisdom can't be told. In S. Vosniadou & A. Ortony (Eds.), *Similarity and analogical reasoning* (pp. 470–497). New York, NY: Cambridge University Press.
- Bransford, J. D., & Schwartz, D. L. (1999). Rethinking transfer: A simple proposal with multiple implications. *Review of Research in Education*, 24, 61–100.
- Butler, R. (1987). Task-involving and ego-involving properties of evaluation: Effects of different feedback conditions on motivational perceptions, interest and performance. *Journal of Educational Psychology*, 79, 474–482.
- Carroll, J. B. (1968). On learning from being told. *Educational Psychologist*, 5(2), 4–10.
- Cohen, J. (1988). *Statistical power analysis for the behavioral sciences*. Hillsdale, NJ: Erlbaum.
- Cortina, J. M. (1993). What is coefficient alpha? An examination of theory and applications. *Journal of Applied Psychology*, 78, 98–104.
- Darnon, C., & Butera, F. (2005). Buts d'accomplissement, stratégies d'étude, et motivation intrinsèque: présentation d'un domaine de recherche et validation française de l'échelle d'Elliot et McGregor (2001) [Achievement goals, study strategies, and intrinsic motivation: presentation of a research field and French validation of Elliot and McGregor's (2001) scale]. *L'Année Psychologique*, 105, 105–131.
- Darnon, C., Butera, F., & Harackiewicz, J. M. (2007). Achievement goals in social interactions: Learning with mastery vs. performance goals. *Motivation and Emotion*, 31(1), 61–70.
- Darnon, C., Butera, F., Mugny, G., Quiamzade, A., & Hulleman, C. (2009). "Too complex for me!" Why do performance-approach and performance-avoidance goals predict exam performance? *European Journal of Psychology of Education*, 24, 423–434.
- Darnon, C., Dompnier, B., Gilliéron, O., & Butera, F. (2010). The interplay of mastery and performance goals in social comparison: A multiple-goal perspective. *Journal of Educational Psychology*, 102(1), 212–222.
- Darnon, C., Muller, D., Schrager, S., Pannuzzo, N., & Butera, F. (2006). Mastery and performance goals predict epistemic and relational conflict regulation. *Journal of Educational Psychology*, 98, 766–776.
- Detterman, D. K. (1993). The case for the prosecution: Transfer as an epiphenomenon. In D. K. Detterman & R. J. Sternberg (Eds.), *Transfer on trial: Intelligence, cognition and instruction* (pp. 1–24). Westport, CT: Ablex.
- Dweck, C. S., & Leggett, E. L. (1988). A social-cognitive approach to motivation and personality. *Psychological Review*, 95(2), 256–273.
- Elliot, A. J. (1999). Approach and avoidance motivation and achievement goals. *Educational Psychologist*, 34(3), 169–189.
- Elliot, A. J. (2005). A conceptual history of the achievement goal construct. In A. J. Elliot & C. S. Dweck (Eds.), *Handbook of competence and motivation* (pp. 52–72). New York, NY: Guilford Press.
- Elliot, A. J., & Church, M. A. (1997). A hierarchical model of approach and avoidance achievement motivation. *Journal of Personality and Social Psychology*, 72, 218–232.
- Elliot, A. J., & Harackiewicz, J. M. (1996). Approach and avoidance achievement goals and intrinsic motivation: A mediational analysis. *Journal of Personality and Social Psychology*, 70, 461–475.
- Elliot, A. J., & McGregor, H. A. (1999). Test anxiety and the hierarchical model of approach and avoidance achievement motivation. *Journal of Personality and Social Psychology*, 76, 628–644.
- Elliot, A. J., & McGregor, H. A. (2001). A 2 × 2 achievement goal framework. *Journal of Personality and Social Psychology*, 80, 501–519.
- Elliot, A. J., McGregor, H. A., & Gable, S. L. (1999). Achievement goals, study strategies, and exam performance: A mediational analysis. *Journal of Educational Psychology*, 91, 549–563.
- Elliot, A. J., & Murayama, K. (2008). On the measurement of achievement goals: Critique, illustration, and application. *Journal of Educational Psychology*, 100, 613–628.

- Elliot, A. J., Shell, M. M., Henry, K. B., & Maier, M. A. (2005). Achievement goals, performance contingencies, and performance attainment: An experimental test. *Journal of Educational Psychology*, 97, 630–640.
- Elliott, E. S., & Dweck, C. S. (1988). Goals: An approach to motivation and achievement. *Journal of Personality and Social Psychology*, 54, 5–12.
- Finney, S. J., Pieper, S. L., & Barron, K. E. (2004). Examining the psychometric properties of the Achievement Goal Questionnaire in a general academic context. *Educational and Psychological Measurement*, 64, 365–382.
- Ford, K. J., Smith, E. M., Weissbein, D. A., Gully, S. M., & Salas, S. (1998). Relationships of goal orientation, metacognitive activity, and practice strategies with learning outcomes and transfer. *Journal of Applied Psychology*, 83(2), 218–233.
- Gick, M. L., & Holyoak, K. J. (1980). Analogical problem solving. *Cognitive Psychology*, 12, 306–355.
- Gist, M. E., & Stevens, C. K. (1998). Effects of practice conditions and supplemental training method on cognitive learning and interpersonal skill generalization. *Organizational Behavior and Human Decision Processes*, 75, 142–169.
- Graham, S., & Golan, S. (1991). Motivational influences on cognition: Task involvement, ego involvement, and depth of information processing. *Journal of Educational Psychology*, 83, 187–194.
- Greeno, J. G. (2006). Authoritative, accountable, positioning and connected general knowing: Progressive themes in understanding transfer. *Journal of the Learning Sciences*, 15, 537–547.
- Greeno, J. G., and the Middle School Mathematics through Application Project. (1998). The situativity of knowing, learning, and research. *American Psychologist*, 53, 5–26.
- Harackiewicz, J. M., Barron, K. E., Pintrich, P. R., Elliot, A. J., & Thrash, T. M. (2002). Revision of achievement goal theory: Necessary and illuminating. *Journal of Educational Psychology*, 94, 638–645.
- Harackiewicz, J. M., Durik, A. M., Barron, K. E., Linnenbrink-Garcia, L., & Tauer, J. M. (2008). The role of achievement goals in the development of interest: Reciprocal relations between achievement goals, interest, and performance. *Journal of Educational Psychology*, 100, 105–122.
- Hickey, D. T. (2003). Engaged participation versus marginal nonparticipation: A stridently sociocultural approach to achievement motivation. *The Elementary School Journal*, 103, 401–429.
- Jaccard, J. (2001). *Interaction effects in logistic regression* (Sage University Papers Series on Quantitative Applications in the Social Sciences No. 07-135). Thousand Oaks, CA: Sage.
- Jagacinski, C. M., Madden, J. L., & Reider, M. H. (2001). The impact of situational and dispositional achievement goals on performance. *Human Performance*, 14(4), 321–337.
- Kaplan, A., & Maehr, M. L. (2007). The contributions and prospects of goal orientation theory. *Educational Psychology Review*, 19(2), 141–184.
- Keppel, G. (1991). *Design and analysis: A researcher's handbook* (3rd ed.). Englewood Cliffs, NJ: Prentice Hall.
- Kirschner, P. A., Sweller, J., & Clark, R. E. (2006). Why minimal guidance during instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching. *Educational Psychologist*, 41(2), 75–86.
- Klahr, D., & Nigam, M. (2004). The equivalence of learning paths in early science instruction: Effects of direct instruction and discovery learning. *Psychological Science*, 15, 661–667.
- Lave, J. (1988). *Cognition in practice*. Cambridge, MA: Cambridge University Press.
- Linnenbrink-Garcia, L., Tyson, D. F., & Patall, E. A. (2008). When are achievement goal orientations beneficial for academic achievement? A closer look at main effects and moderation factors. *International Review of Social Psychology*, 21, 19–70.
- Lobato, J. (2003). How design experiments can inform the rethinking of transfer and vice versa. *Educational Researcher*, 32(1), 17–20.

- Lobato, J. (2006). Alternative perspectives on the transfer of learning: History, issues, challenges for future research. *Journal of the Learning Sciences*, 15, 431–449.
- Malone, T. W., & Lepper, M. R. (1987). Making learning fun: A taxonomy of intrinsic motivation for learning. In R. E. Snow & M. J. Farr (Eds.), *Aptitude, learning, and instruction* (Vol. 3, pp. 223–253). Hillsdale, NJ: Erlbaum.
- McGregor, H. A., & Elliot, A. J. (2002). Achievement goals as predictors of achievement-relevant processes prior to task engagement. *Journal of Educational Psychology*, 94, 381–395.
- Midgley, C., Arunkumar, R., & Urdan, T. C. (1996). “If I don’t do well tomorrow, there’s a reason”: Predictors of adolescents’ use of academic self-handicapping strategies. *Journal of Educational Psychology*, 88, 423–434.
- National Research Council. (2000). *How people learn: Brain, mind, experience, and school*. Washington, DC: National Academies Press.
- Nokes, T. J. (2009). Mechanisms of knowledge transfer. *Thinking & Reasoning*, 15, 1–36.
- Nokes, T. J., & Belenky, D. M. (2011). Incorporating motivation into a theoretical framework for knowledge transfer. In J. Mestre & B. H. Ross (Eds.), *Psychology of learning and motivation: Vol. 55. Cognition in education* (pp. 109–135). San Diego, CA: Academic Press.
- Nokes, T. J., & Ohlsson, S. (2005). Comparing multiple paths to mastery: What is learned? *Cognitive Science*, 29, 769–796.
- Pintrich, P. R. (1999). The role of motivation in promoting and sustaining self-regulated learning. *International Journal of Educational Research*, 31, 459–470.
- Pugh, K. J., & Bergin, D. A. (2006). Motivational influences on transfer. *Educational Psychologist*, 41(3), 147–160.
- Reed, S. K. (1993). A schema-based theory of transfer. In D. K. Detterman & R. J. Sternberg (Eds.), *Transfer on trial: Intelligence, cognition and instruction* (pp. 39–67). Westport, CT: Ablex.
- Reed, S. K., Dempster, A., & Ettinger, M. (1985). Usefulness of analogous solutions for solving algebra word problems. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 11, 106–125.
- Royer, J. M. (1979). Theories of the transfer of learning. *Educational Psychologist*, 14(1), 53–69.
- Ryan, A. M., Gheen, M. H., & Midgley, C. (1998). Why do some students avoid asking for help? An examination of the interplay among students’ academic efficacy, teachers’ social-emotional role, and the classroom goal structure. *Journal of Educational Psychology*, 90, 528–535.
- Schwartz, D. L., & Bransford, J. D. (1998). A time for telling. *Cognition and Instruction*, 16, 475–522.
- Schwartz, D. L., Bransford, J. D., & Sears, D. L. (2005). Efficiency and innovation in transfer. In J. Mestre (Ed.), *Transfer of learning from a modern multidisciplinary perspective* (pp. 1–51). Greenwich, CT: Information Age.
- Schwartz, D. L., & Martin, T. (2004). Inventing to prepare for future learning: The hidden efficiency of encouraging original student production in statistics instruction. *Cognition and Instruction*, 22, 129–184.
- Senko, C., Hulleman, C. S., & Harackiewicz, J. M. (2011). Achievement goal theory at the crossroads: Old controversies, current challenges, and new directions. *Educational Psychologist*, 46(1), 26–47.
- Singley, M. K., & Anderson, J. R. (1989). *The transfer of cognitive skill*. Cambridge, MA: Harvard University Press.
- Somuncuoglu, Y., & Yildirim, A. (1999). Relationship between achievement goal orientations and use of learning strategies. *Journal of Educational Research*, 92(5), 267–277.
- Tabachnik, B. G., & Fidell, L. S. (2007). *Using multivariate statistics* (5th ed.). Boston, MA: Allyn & Bacon.
- Urdan, T., & Schoenfelder, E. (2006). Classroom effects on student motivation: Goal structures, social relationships, and competence beliefs. *Journal of School Psychology*, 44, 331–349.

Utman, C. H. (1997). Performance effects of motivational state: A meta-analysis. *Personality and Social Psychology Review*, 1(2), 170–182.

Wolters, C. A. (2004). Advancing achievement goal theory: Using goal structures and goal orientations to predict students' motivation, cognition, and achievement. *Journal of Educational Psychology*, 96, 236–250.

APPENDIX A

The Logistic Model Predicting Transfer From the Type of Learning Activity Completed, the Presence or Absence of the Worked Example, and Their Interaction

$$\ln (P_{Transfer}/1 - P_{Transfer}) = f [a + b_{LearningActivity} \times LearningActivity + b_{WorkedExample} \times WorkedExample + b_{LearningActivity \times WorkedExample} \times (LearningActivity \times WorkedExample)]$$

APPENDIX B

The Logistic Model Predicting Transfer From the Four Orientation Scores: Mastery-Approach, Performance-Approach, Mastery-Avoidance, and Performance-Avoidance

$$\ln (P_{Transfer}/1 - P_{Transfer}) = f [a + b_{Mastery-Approach} \times Mastery-Approach + b_{Performance-Approach} \times Performance-Approach + b_{Mastery-Avoidance} \times Mastery-Avoidance + b_{Performance-Avoidance} \times Performance-Avoidance]$$

APPENDIX C

The Logistic Model Predicting Transfer From the Type of Learning Activity, Mastery-Approach Orientation Score, and Their Interaction

$$\ln (P_{Transfer}/1 - P_{Transfer}) = f [a + b_{LearningActivity} \times LearningActivity + b_{Mastery-Approach} \times Mastery-Approach + b_{LearningActivity \times Mastery-Approach} \times (LearningActivity \times Mastery-Approach)].$$