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The Role of Achievement Goal Motivation in Self-Explanation and Knowledge Transfer

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Abstract

Self-explanation is an important constructive cognitive process that helps students learn in such a way that they can flexibly transfer their knowledge to solve novel problems (Chi, Bassok, Lewis, Reimann, & Glaser, 1989). However, research has not addressed what leads students to spontaneously self-explain, in the absence of prompting. The present study experimentally manipulates student motivation (in terms of achievement goals) and measures what influence this has on self-explanation and transfer. Participants (N = 140) received goal framings that reflected either a mastery-approach goal (striving to develop one's understanding), a performance-approach goal (an aim to outperform others), a performance-avoidance goal (avoid doing worse than others) or a no-goal control. This framing was applied to a set of learning and test tasks on basic statistics, which participants completed while thinking aloud. Results showed a benefit for a performance-avoidance condition in terms of both higher levels of self-explanation and transfer. This unexpected result is discussed in terms of theories of motivation and learning, and their potential impact on educational practice.

Keywords: Knowledge Transfer, Motivation, Achievement Goals, Self-Explanation, Education

Introduction

A fundamental goal of instruction is to foster learning which leads to successful, flexible, and useful knowledge transfer. Research and theoretical development which elucidates how knowledge transfers has a long history in psychology and cognitive science, and continues to be important for educational psychologists and learning scientists. Continuing to advance our understanding of what sorts of learning activities lead to transfer allows for recommendations on how to improve educational practices.

Evidence has accumulated that a promising method for promoting flexible knowledge transfer is to increase the conceptual quality of the original learning (Pashler et al., 2007). As such, constructive learning processes which promote the acquisition of more abstracted knowledge (e.g., schemas) are likely to promote successful knowledge transfer. A representative example of such a process is self-explanation (Chi, Bassok, Lewis, Reimann, & Glaser, 1989), which is the process by which students generate, for themselves, explanations which go beyond the text, inferring underlying principles and highlighting important interrelations. Chi et al. (1989) documented a large difference in the amount and quality of self-explanations between those students who ultimately go on to flexibly transfer their knowledge and those who do not. A number of studies since have documented that students can be prompted to engage in self-explanation (e.g. Aleven & Koedinger, 2002) with beneficial effects for learning and knowledge transfer. However, a fundamental question about self-explanation has been left unaddressed; what leads students to engage in self-explanation, in the absence of prompting? It is clear that some students do so, to their benefit, while others do not. It is also likely that whether students are capable of self-explaining profitably is not the sole limitation, given the experimental literature which shows a benefit for self-explanation prompts. In the present research, we address the possibility that student motivation leads to the spontaneous use of self-explanation during learning, and that this can influence the likelihood of successfully transferring. While Chi et al. (1989) conjectured that higher levels of self-explanation are "a natural consequence of wanting to understand the solution example better" (pg. 160), no research has systematically tested this claim. As we will review in the subsequent section, this sort of motivation has been studied extensively by researchers of "achievement goal theory," which has documented just such a desire, labeling it a "mastery-approach" goal. The present study leverages achievement goals as a tool for experimentally investigating how motivation influences self-explanation and transfer.

Achievement Goal Motivation

Achievement goals are the reasons people have for engaging in achievement settings, such as school or work. An achievement setting is one that is organized around one's *competence* in a domain, and an achievement goal describes a goal a person has in relation to this competence, such as wanting to use it demonstrate how good they are in this domain, or wanting to develop their competence so that they can complete more challenging work. A large body of research and theory development has led to a generally-accepted framework which proposes three main classes of goals (Elliot, McGregor, & Gable, 1999); mastery-approach, performance-approach, and performance-avoidance. A mastery-approach goal is an aim to improve or develop one's competence or understanding. A performance-approach goal reflects striving to demonstrate one's competence by doing better than one's peers, while a performance-avoidance goal occurs when one strives not to demonstrate one's incompetence, compared to peers[1].

Research has shown that these goals produce a characteristic pattern of effects on various learning behaviors, affective states, and measures of performance. Specifically, performance-avoidance goals tend to be associated with negative outcomes, such as lower performance and worse study strategies (e.g., Elliot, Shell, Henry & Maier, 2005, Elliot, McGregor, & Gable, 1999). Performance-approach goals have been associated with a mixed pattern of results, such that they are sometimes associated with positive effects on grades, but also with more shallow learning strategies (e.g., Elliot, McGregor, & Gable 2001). Mastery-approach goals tend to be associated with positive affective outcomes, such as increased interest (Harackiewicz, Barron, Pintrich, Elliot, & Thrash, 2002). Results relating to grades are inconsistent, with the majority of studies finding no relationship between grades and transfer (Linnenbrink-Garcia, Tyson, & Patall, 2008). Critically for understanding the present study, mastery-approach goals have been linked to better performance on more difficult tasks (Utman, 1997), as well as self-reported constructive learning processes (e.g., Elliot, McGregor, & Gable, 1999). Additionally, a small number of studies have documented a link between mastery-approach goals and knowledge transfer (e.g., Belenky & Nokes-Malach, 2012).

It is important to note that the prevailing method for measuring achievement goals in this research literature is through self-report questionnaires and assessed at the level of academic courses. That is, goals for a particular course are assessed at the beginning of a semester and then are correlated to self-reports of learning behaviors collected during the semester, as well as achievement measures such as grades on a final exam. However, this "course-based" style of measurement may inadvertently measure more than goal motivation. That is, it may reflect other personality characteristics (e.g., Need for Cognition; Cacioppo & Petty, 1982), beliefs (e.g., Naïve theories of intelligence, Dweck, 1999) and other variables that are not motivation, per se. Developing a strong theory of how motivation influences behavior requires a narrower focus on a task-by-task basis.

As such, in the current study, we focus on "task-based" achievement goals, and draw upon the literature that experimentally manipulates these goals for a given task. In studies of this nature experimenters provide some information to frame the task for participants in such a way that leads to the adoption of a particular achievement goal.

The question addressed in the present research is whether one can produce a change in self-explanation behaviors by manipulating motivation for the task, such that a benefit is observed for knowledge transfer. Specifically, we test the hypothesis that manipulated mastery-approach goals predict increased self-explanation, compared to performance-approach or performance-avoidance goals. Additionally, we expect that the mastery-approach condition will produce higher levels of transfer, as observed for course-based goals in prior research using similar materials (Belenky & Nokes-Malach, 2012).

[1] Readers familiar with achievement goal research may note the exclusion of mastery-avoidance goals in this discussion. As these goals are a newer addition to the field, and have less empirical studies to establish their effect on learning and transfer, they are not a focus of the current work.

Method

Participants

The participants were 140 undergraduates from the University of Pittsburgh, who participated in exchange for course credit. The first 105 participants were randomly assigned to the mastery-approach, performance-approach, or performance-avoidance conditions (35 each). The no-goal control was collected the following academic semester.

Materials

The materials were presented to participants in binders. Within each packet was a pre-test, a set of learning activities, activity questionnaires, a post-test, and a final set of questionnaires.

Learning Activities. The learning materials were adapted from the "Tell-and-Practice" materials used in prior research (Belenky & Nokes-Malach, 2012; Schwartz & Martin, 2004). These materials comprise worked examples and problems that introduce, model, and give practice problems on two basic statistical concepts; mean deviation and standardized scores.

Specifically, participants first received a worked example on how to calculate mean deviation, which demonstrates the standard procedure. This was followed by a learning activity problem that presented data from four pitching machines and asked the participant to decide which of the four is the most reliable. The datasets are designed in such a way that contrasting between them should help focus participants' attention to the critical features of the mean deviation formula (and their conceptual underpinnings), such as the number of data points, the spread, etc. However, with the tell-and-practice nature of the activity, these aspects could be ignored in favor of a "plug-and-chug" method.

After completing this problem, participants moved on to the next worked example, which described a scenario where two students in different classes want to know who did better on a test, given that their teachers may grade differently. The worked example showed the participant how to draw a histogram for each of the classes, and then how to map the given information about means, mean deviations, and the particular students' scores onto the histogram. Finally, it explains how the participant can use this information to decide which is better. This procedure is roughly equivalent to graphically estimating a standardized score. Immediately following this worked example was another learning activity problem; this one asked students to decide which of two world records, from two different track and field events, was "more shattered." Students were given a set of scores from two different events and two exceptional values for each, and told to use the procedure they had just learned to help them decide which had a more impressive performance, given the rest of the competitors.

Test Materials. The pre-test consisted of a procedural fluency measure, a transfer problem, and a graphical representation problem. The post-test included, in order, three procedural fluency items, a worked example on standardization, a mean deviation word problem, an open-ended explanation problem, and a transfer problem. This manuscript will focus exclusively on the transfer measures, which dealt with the target concept of using standardized scores to compare values from two different distributions. These problems presented an exceptional value from each of two different distributions, along with their means and standard deviations, and asked the participant to decide which of the two values was more impressive. One problem dealt with the distance of homeruns, and the other with scores on a driving test. Correctly solving these problems requires calculating a standardized score, so that the degree to which each value is exceptional, compared to the distribution it comes from, can be determined.

In accordance with research on transfer as Preparation for Future Learning, a worked example was embedded in the post-test, a few problems before the transfer. This worked example describes a scenario (with data) in which a standardized score is needed to help determine which of two performances in different athletic events was better, demonstrates the formula for a calculating a standardized score, and uses that formula to solve the problem. This is followed by another very simple problem and a prompt to use the formula to solve it, which all participants solved correctly. Correctly solving the subsequent transfer problem indicates that participants learned this procedure well, and understood that it could help them solve problems where they need to compare across two different distributions.

Activity Questionnaires. Following the learning activities, participants completed two pages of questionnaires. The first page contained a manipulation check modeled on prior research (e.g., Elliot et al., 2005). The second measured their task-based goal adoption during the learning activity, which serves as another measure to ensure that the goal manipulations produced the anticipated effects. The manipulation check asked students "At the beginning of the learning phase, you were asked to focus on just one goal for this study. What was it?" (the manipulation will be described in the next section). It asked participants to check only one of the possible responses, which corresponded to performance-avoidance, performance-approach, and mastery-approach.

The second page was a measure of their achievement goal adoption during the just-completed learning phase. Specifically, this questionnaire had six Likert-scale (1-7) items that each started with the stem, "While completing these activities," which was followed by descriptions of either a mastery-approach (skill development and improved understanding), performance-approach (doing better than others), and performance-avoidance (not doing worse than others) goal. Two items of each of these goal types was included, and, after ensuring that they had adequate reliability (Cronbach's $\alpha = .65$ for mastery-approach, .84 for performance-approach, .88 for performance-avoidance) a construct score was created for each by averaging across the two items.

Final Questionnaires. The questionnaires administered at the end of the experiment assessed participants' task-based goal and strategy adoption during the experiment, their course-based achievement goals for mathematics, self-reported strategy usage during the experiment, and demographic information. These will not be addressed in the current manuscript, but the general pattern of results on the goal-related measures was similar to that on the activity questionnaire and manipulation check, which will be presented in the results section.

Procedure

The procedure followed the order of the packet, with additional instructions provided by the experimenter on the talk-aloud protocol and the goal manipulation, which both occurred after the pre-test. Specifically, the procedure consisted of: pre-test (5 minutes), talk-aloud training (2 minutes), goal manipulations (5 minutes), learning activities and activity questionnaires (20 minutes), post-test (20 minutes), final set of questionnaires, and a short debriefing (~8 minutes). Important aspects of the procedure carried out by the experimenter will be described next.

Talk-Aloud Training. After the pre-test, the experimenter informed the participants that they would be recorded as they talked aloud during parts of the experiment. To practice doing so, participants were given a sheet with simple arithmetic problems and asked to talk aloud as they solved them. The experimenter listened and gave corrective feedback if participants were not talking aloud properly (i.e., without reflection, but simply saying what was in their working memory at the time; see Ericsson & Simon, 1993).

Goal Manipulations. After the talk-aloud training, participants in the experimental conditions received the goal manipulation. The manipulations focused on the reasons that the study was being conducted, and how that should influence the goals participants should adopt as they went through the study. These were constructed based on reported studies (e.g., Elliot et al., 2005) and were delivered verbally by the experimenter in a conversational manner, as additional information about the study. Specifically, all participants first heard a general statement about how people can have different goals in different situations before receiving the manipulation specific to their condition. Among other aspects of the manipulation (see Table 1), the mastery-approach condition was told that their goal should be "to develop your understanding of these materials and your skill in solving these types of problems." The performance-approach condition was told to focus on the

Table 1: Representative Excerpts from the Goal Manipulations

Mastery-Approach	Performance-Approach	Performance-Avoidance
...we are interested in developing a set of materials that help students learn this material well. *... I really want you to ... try to develop your understanding of these materials* *....At the end of the study, I will ... give you feedback on how you much you improved from the beginning of the study to the end*	*... we are trying to find those (students) that produce better performance than most of the other participants.* *. focus on trying to perform better than the majority of other participants throughout the study...* *.... At the end of the study, I ... give you feedback on how you performed relative to other participants…*	*...we will examine each person's performance and compare it to other students to find instances when people do particularly poorly* *... try and not perform any worse than the majority of other participants throughout the study* *... At the end of the study, I will ... give you feedback on how you performed relative to other participants…*

goal "to perform well compared to other participants." The performance-avoidance condition was told their goal should be "to not perform poorly compared to other participants."

Protocol Coding

Transcriptions were made of the verbalizations participants produced during the learning phase, the worked example in the test, and the transfer problem. These were then broken down into utterances (defined as one classifiable thought, usually at the level of a sentence). Each utterance was then coded according to a rubric which was developed based on prior research on self-explanation, and refined to reflect the statements made by participants through a process of iterated revisions. Although the full rubric covered a number of categories, this manuscript will focus on a small set that were *a priori* considered the most theoretically interesting. In particular, we focus on those statements coded as self-explanations and as comparisons between the transfer problem and the earlier worked example, as these are considered strong evidence of constructive learning processes (Renkl, 1997).

Results

The first set of analyses deal with the question of how successful the manipulations were in influencing goal adoption. The two measures of goal adoption reported here are the manipulation check – which asked participants in the three experimental conditions to recall the goal they had been asked to focus on – and the activity questionnaire.

The forced-choice manipulation check clearly demonstrated that participants knew which goal they were asked to focus on, χ^2 (4, N = 105) = 176.35, p <.001, with 94% of the participants in the experimental conditions correctly choosing their condition. Each of the activity questionnaire goal adoption scores (calculated as described in the methods section) were also analyzed in separate one-way ANOVAs. There were significant differences between the three conditions for each of the mastery-approach, performance-approach, and performance-avoidance goal adoption scores, Fs (2, 102) > 9.35, ps < .001.

Additionally, a series of planned comparisons was conducted between each pair of conditions on each goal adoption score. On the measure of mastery-approach goal adoption, the mastery-approach condition was significantly higher than the performance-approach, t (68) = 2.59, p = .012, and performance-avoidance, t (68) = 4.13, p < .001, conditions on mastery-approach goal adoption, but not significantly different from the control condition, t(68) = 1.53, p = .130, (see Table 2). For performance-approach goal adoption, the performance-approach condition was significantly higher than the mastery-approach, t (67) = 9.17, p < .001, or control condition, t (68) = 6.36, p < .001 but not significantly higher than the performance-avoidance condition, t(67) = 1.90, p = .062. Finally, performance-avoidance goals were adopted the least by the mastery-approach condition, ts (68) > 4.42, ps < .001. All other conditions did not differ statistically in their performance-voidance goal adoption, ts (68) < .86, ps > .39.

All told, the manipulations clearly created a different pattern of results across the mastery, control, and performance conditions. However, the performance-approach and performance-avoidance conditions did not differentiate as cleanly.

Table 2: Activity Questionnaire Means (and Standard Deviations).

	Activity Mastery-Approach	Activity Performance-Approach	Activity Performance-Avoidance
Mastery-Approach	11.31 (2.19)	5.24 (3.20)	5.51 (3.37)
Performance-Approach	9.94 (2.24)	11.63 (2.57)	9.89 (3.05)
Performance-Avoidance	8.74 (2.96)	10.44 (2.63)	9.83 (3.62)
Control	10.43 (2.63)	7.17 (3.26)	9.20 (3.58)

Goals and Transfer

Given that the manipulations seemed to produce the desired goal adoption, we turn to the first hypothesis; namely, that mastery-approach goals would lead to better transfer. As the transfer problem was coded dichotomously, correct or incorrect, logistic regression was used to assess differences between the conditions in the likelihood of correctly solving the transfer problem. The logistic regression model predicting the likelihood of transfer based on the categorical variable of condition was significant, χ^2 (3, N = 140) = 11.24, p = .011. This analysis revealed that both the control (54%) and mastery-approach (49%) conditions were significantly less likely to transfer than the performance-avoidance condition (83%). There was no significant difference between the performance-approach (69%) and the other three conditions.

While the mastery-approach condition did not increase the likelihood of transfer, it is possible that the degree to which a student adopts a mastery-approach goal would benefit transfer. To analyze this prediction, goal adoption (as measured by the construct scores from the activity questionnaire) was entered as a predictor of a transfer in a logistic regression model. This model was significantly better than a constant-only model, χ^2 (3, N = 140) = 11.92, p = .008. Within this model, the only variable which is significantly different from zero is the performance-approach construct score, Wald's χ^2 (1, N = 140) = 9.36, p = .002, *Exp (B)* = 1.19. For every unit increase in adopted performance-approach goals, the likelihood of transfer increased by 19%.

To summarize, it appears that mastery-approach goals did not lead to an increased likelihood of transfer[2]. Instead, the performance-avoidance condition had the highest levels of transfer, and, in terms of goal adoption, only the degree to which performance-approach goals were endorsed predicted transfer.

Goals and Self-Explanation

The second hypothesis being investigated was that mastery-approach goals would lead to more self-explanation. Results for the three experimental conditions are reported here, as coding for the control condition remains ongoing. One participant from the mastery-approach condition is not included in these analyses, as her think aloud data was lost due to a technical error.

There were no significant differences between the experimental conditions in the number of self-explanations made overall, F (2, 101) = .01, p = .995, or on time spent making self-explanation statements, F (2, 101) = .93, p = .40. Subsequent analyses examined self-explanations made during each of the particular components of the study that were coded (the learning phase, worked example, and transfer problem). There were no differences between the conditions on self-explanations made during the learning phase, F (2, 101) = .37, p = .689. For the worked example on standardization, there was a significant difference between conditions, F (2, 101) = 4.00, p = .021, η^2 = .073. Post-hoc analysis revealed a higher degree of explanation statements for the performance-avoidance condition (M = .94, SD = 1.49) compared to the performance-approach condition (M = .37, SD = .54) and the mastery-approach condition (M = .38, SD = .49). Finally, for the transfer problem, there was no difference between conditions on self-explanation, F (2, 101) = 2.39, p = .097.

The other type of constructive learning behavior that was analyzed was comparisons back to the worked example during the transfer problem. For example, statements like "So we'll just, um do that procedure we were doing before… like the standardized number" were coded as referencing back to the worked example. There were significant differences in this type of elaboration, F (2, 101) = 3.15, p = .047, η^2 = .059. Post-hoc analysis revealed that the performance-avoidance condition (M = .37, SD = .60) produced significantly more of these statements than the performance-approach condition (M = .06, SD = .24), but there were no differences between the mastery-approach condition (M = .26, SD = .67) and either of the other two.

In summary, the performance-avoidance condition generated the most self-explanation statements during the worked example. Additionally, this condition referenced the worked example more during the transfer problem than the performance-approach condition.

Discussion

The current study experimentally manipulated achievement goals for a learning and transfer task, and found that a performance-avoidance goal manipulation had a positive effect on transfer. This condition produced the most self-explanations during the worked example, and made the most references back to the worked example during the transfer problem. This is a different pattern of results than was expected, as course-based performance-avoidance goals are usually associated with negative outcomes, and almost never associated with positive ones. We will discuss possible reasons for these results, and describe how future research can confront the issues this research presents.

One obvious possibility is that task-based and course-based goals do not reflect the same constructs, and produce different effects. As discussed earlier, measures of course-based achievement goals may reflect other individual differences, like personality traits and beliefs. These (typically unmeasured) individual differences may in fact be responsible for the observed pattern of results found in prior research, rather than achievement goals themselves. Benefits that have been associated with course-based mastery-approach goals (e.g., interest, better study strategies, transfer) may actually be due to individual differences like need for cognition (Cacioppo & Petty, 1982) or incremental theories of intelligence (Dweck, 1999), which may lead to both a higher level of mastery-approach goal endorsement, as well as self-reports of positive learning behaviors and grades. If this were so, manipulations that only target task-based goals would be unlikely to aid learning. However, this is somewhat contradicted by the present results, which do find a benefit for performance-avoidance goals. It will be important for researchers to consider in what ways course-based and task-based goals are similar and in what ways they are different.

While the performance-avoidance condition did seem to perform the best, other measures indicate that it may be premature to tout the utility of this type of goal. Students in both performance goal conditions reported similar goal adoption, and only performance-approach goal adoption was predictive of transfer. The current results indicate that

[2] The same pattern of results is observed when controlling for pre-test transfer performance.

performance goals may help guide students towards generating explanations and knowledge transfer, but research on the relative impact of each type of goal is needed. This is especially important giving the general consensus in the literature that performance-avoidance goals do not aid learning.

An interesting avenue for future research will be to explore how different types of learning activities can influence motivational effects. It is possible that performance-avoidance goals are particularly beneficial for learning simply material and for nearer transfer, compared to more challenging materials. Participants may have perceived the learning materials in this study as quite straightforward. For example, correctly solving the transfer problem required a direct application of the procedure in the worked example to the transfer problem. The performance-avoidance condition produced more self-explanation during the worked example, and referenced the worked example during the transfer problem more frequently than the other conditions, indicating a relatively direct transfer of knowledge. Mastery-approach goals may benefit "further" transfer than what was required for this task. Using goal manipulations across a variety of learning and performance tasks will allow for a richer picture to emerge. Research on regulatory fit (e.g. Higgins, 2000), for example, has shown that prevention goals (similar to avoidance goals) improve performance in tasks organized around minimizing losses, while promotion goals (similar to approach goals) help with tasks based on maximizing gains. Similar interactions may occur between achievement goals and different task structures encountered while learning.

While the results did not support the hypothesis that mastery-approach goals promote self-explanation and transfer, the study did achieve one of its aims. Specifically, a short motivational intervention produced a change in task-based goals, which led to different levels of self-explanation and transfer. While important questions were raised as to which goal may be most beneficial in which settings, the fundamental premise (that goals influence learning behaviors and transfer) was supported. This research can provide a basic paradigm for further inquiry.

The study of motivation in academic settings is a fruitful enterprise, as it can inform both cognitive psychology theories of how people learn, as well as educational practice to improve learning outcomes. Future research should continue to address what influence *adopted* goals have on behavior, as theories of motivation are useful inasmuch as they can be used to predict behaviors. Measures of course-based goals seem quite predictive of long-term success, and of certain *self-reported* attitudes, behaviors, and affective experiences, but it is less clear what effect they have on moment-to-moment behaviors. More broadly, incorporating motivation into theories of learning and knowledge transfer (see Nokes & Belenky, 2011) remains an important goal for cognitive scientists who wish to have an impact on educational practice, while also furthering our understanding of the human cognitive architecture.

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