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G. Herold Poelzer

Liang Zeng

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By G. Herold Poelzer and Liang Zeng

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This quasi-experimental pilot study of nonscience majors taking a physical science course at a university in South Texas applied attribution theory as a teaching intervention to improve test scores. That the treatment group outperformed the comparison group provides evidence of the positive effect of having students reflect on controllable reasons for their grades and on their subsequent planning of strategies to maintain or improve those grades.

Interesting perceptions exist regarding both nonscience majors taking physical science courses, and physical science courses themselves. Professors perceive these students to have relatively weak backgrounds in science and math (Duchovic et al. 1998), to have little interest in learning science (Beiswenger, Stepans, and McClurg 1998), to be unmotivated, to have relatively poor study habits, and to have relatively poor achievement. And they perceive physical science courses as having, at most, the rigor of a basic high school science course. The physical science course content in this particular study consists of mechanics, thermodynamics, electricity, magnetism, and astronomy; the prerequisite for the course is intermediate algebra.

Much concern, then, is directed toward understanding what main factors influence the achievement in physical science of nonscience majors, so that intervention strategies can be applied. Some studies have focused on the number of study hours outside of class (Lahmers and Zulauf 2000), and some on the quality of study hours outside of class (Michaels and Miethe 1989). Other studies have looked at age, major, employment, and so on. Most studies have been descriptive or qualitative studies. This pilot study differs from previous studies in that it is quasi-experimental, was conducted on Hispanic undergraduate students, and is theory based—an application of attribution theory.

Attribution theory suggests that people ascribe reasons or attributes for their performances, and that these attributes affect subsequent behavior and feelings, and thus influence their motivation to achieve (Gage and Berliner 1998; LeFrancois 1995; McCormick and Pressley 1997; McCown, Driscoll, and Roop 1996; Santrock 2001). The three properties that account for the attributes are locus (internal or external), stability (stable or unstable), and controllability (controllable or uncontrollable) (Weiner 2000). Bong (2001); Pajares and Miller (1994); Zimmerman and Bandura (1994); and Zimmerman, Bandura, and Marinez-Pons (1992, as cited in Slavin 2003) emphasize the importance of controllability in student achievement. For example, successful students attribute their successes and failures to things they can control, whereas unsuccessful students attribute their successes and failures to things they cannot control.

Review of the literature

A variety of studies have been conducted on attribution theory and its relationship to motivation, self-concept, achievement, self-efficacy, failure, and the like. Ziegler and Stoeger (2004) conducted a study on the top 20% of students entering a grade 9 chemistry class in Germany that used modeling to train students to attribute their successes and failures to internal and external causes that are controllable. They found that the females in the treatment group not only achieved higher grades than females in the control group, but also attributed more of their successes to internal-variable causes such as work input and less to external-stable causes such as unchallenging tests.

In their sample of 684 students (representing India, Japan, South Africa, the United States, and Yugoslavia) between the ages of 19 and 24 enrolled in education, social science, and physical science, Chandler et al. (1981) found that, overall, participants attributed their successes to effort, and their failures to lack of effort—an attribute that is controllable. On average, however, participants attributed their successes to effort, ability, luck, and context (e.g., task difficulty), respectively; and their failures to lack of effort, context, bad luck, and lack of ability, respectively. Effort and ability are internal attributes, but only effort is controllable, whereas luck and context are external attributes that are not controllable.

Kurtz-Costes and Schneider (1994) argue that children with high self-esteem who believe that they are achievers and that success is due to ability and effort are likely to expend the effort necessary to achieve, whereas children who also have high self-esteem but who believe that success is the result of external factors (such as task difficulty) are likely to give up when confronted with a difficult task.

Li and Adamson (1995) found that the siblings of gifted children in secondary school science attributed successes to good effort and good strategies and their failures to lack of effort rather than to lack of ability. The gifted children, on the other hand, attributed task easiness to their successes.

Our study poses the following questions: Will the predominately Hispanic nonscience majors taking physical science follow this same pattern in attributing successes and failures? Will they employ the same study strategies that brought them success on one test to prepare for their next test? Will they modify their study strategies that resulted in failure on one test to eliminate failure on the next test? Will the practice of completing the *Attributional Rating Form for Test Scores* (ARFTS) (Alderman, 2004, p. 39) increase achievement?

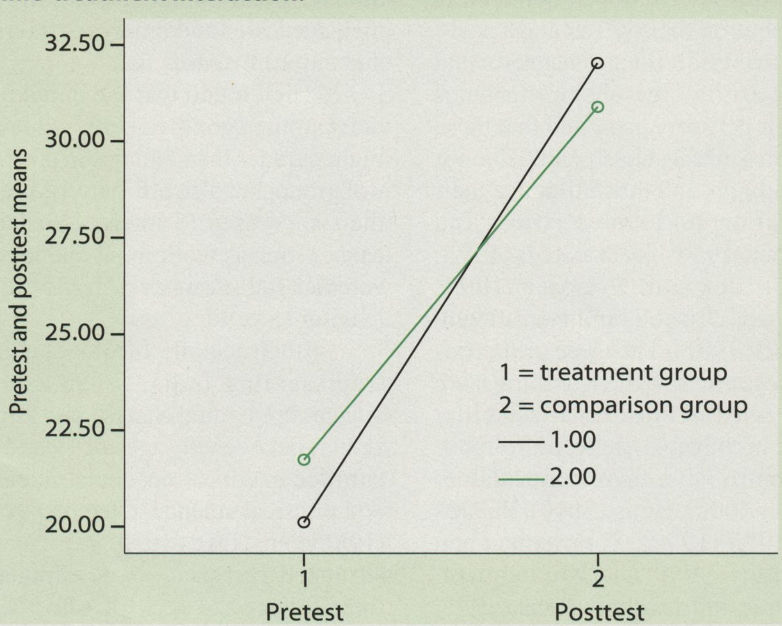
TABLE 1

Descriptive analysis of test scores.

Group	Sample	Pretest scores mean	Posttest scores mean	Gain scores mean	Standard deviation	Standard error of gain scores mean
Treatment	$n_1 = 36$	20.11	32.2	$M_1 = 11.9$	$s_1 = 6.00$	$SE_1 = 1.00$
Control	$n_2 = 20$	21.7	30.9	$M_2 = 9.15$	$s_2 = 4.96$	$SE_2 = 1.11$

FIGURE 1

Time-treatment interaction.



Methods and procedures

Research design

This study is a quasi-experimental mixed design (quantitative and qualitative) using a pretest and posttest, with a treatment and a comparison group. In a quasi-experimental design, intact groups (treatment and comparison) are selected. Both groups receive the pretest and posttest, but only the treatment group receives the treatment. In this study, both groups were given the extra task of keeping a log of study hours outside of class that was turned in to the instructor on a weekly basis. This task allowed us to give attention to both groups and avoid the Hawthorne effect, which links performance to the amount of attention a group receives (Bachara and Zaba 1978; Hamilton, Pritchard, and Welsh 2002; Harris 2002; McCambridge and Strang 2005; Reading 2004; Tan 2004; Troia 1999). This allowed us to attribute any change in performance to the treatment rather than the attention. Having students keep a log also allowed us to gather information concerning the time students spent on studying outside class, as well as the quality of their study sessions. In addition, one of the researchers conducted interviews with a randomly selected focus group from each of the treatment and comparison groups. The purpose of the interviews was to garner information from students that could help to interpret the results of the study. One of two classes was randomly assigned to be the treatment group (36 students), and the other class (20 students) was the comparison group.

Participants

The study was conducted at a university in South Texas, where 87% of the student population is Hispanic. The sample consists of 56 Hispanic nonscience majors enrolled in two sections of a physical science course taught by one professor using the lecture method of instruction in both sections in fall 2006. These freshmen, sophomores, juniors, seniors, and postbaccalaureates account for over 23 majors in the following five colleges: education, arts and humanities, social and behavioral sciences, business administration, and health sciences and human services. The sample included 36 females, 20 males, 23 freshmen, 21 sophomores, 10 juniors, 1 senior, and 1 postbaccalaureate. Other demographics were not pursued in this pilot study.

Instruments

The comprehensive pretest (posttest) consists of 48 multiple-choice questions pertaining to mechanics (27), thermodynamics (5), electricity and magnetism (9), and astronomy (7), respectively. The number of questions in each section reflects the emphasis placed on that topic. These items mimic the items on the unit tests that focus on enhanced factual knowledge, as well as conceptual knowledge.

The ARFTS requires students to state whether they consider their test scores a success or nonsuccess, what they attribute to this success or nonsuccess, how they prepared for the test, and how they plan to prepare for their next test. This form was developed by the instructor of the Learning Framework course for freshmen (UNIV 1301). The weekly logs of study hours and quality require students to report each study session that occurred during the week and to include the location, the time duration, the content studied, the physical and social environments, and any distracters experienced. In addition, they rate the quality of each of these study log components on a scale of 1 to 4 with the descriptors poor, acceptable, good, and very good, respectively. They also sum the number of study sessions and study hours, and rate the overall quality for the entire week.

Administration

The treatment group received the ARFTS along with the results of a unit test; they completed the form and returned it to the instructor within one week. This procedure was repeated four times, once for each of the four units covered in the course. Both treatment and comparison groups kept logs of study hours and quality of study hours that they turned in to the instructor on a weekly basis. The pretest was administered two weeks into the fall 2006 semester and a posttest at the end of the semester.

Analysis

The SPSS 13.0 was used to perform the following: a descriptive analysis of the pretest and posttest scores, and a two-by-two factorial ANOVA with repeated measures on the time factor to analyze the time-treatment interaction effect. Because relatively low numbers of faculty, groups, and group members lessen the ability of the analyses to detect important differences in treatment effects, the alpha level was set at 0.10. Hall et al. (2004) also used an alpha level of 0.10 in their study of the effects of attribution training to compensate for the broad range of experiences and environments encountered when using GPAs, school grades, and individual differences in elaborative learning that could hide differential treatment effects. The interaction effect was paramount because it indicates whether the treatment group has a greater increase in achievement than the comparison group. Increase in achievement is measured by gain scores, which are calculated by subtracting pretest scores from posttest scores.

An effect size was calculated to evaluate the practical extent of learning. An effect size in true experimental and quasi-experimental designs is a z-score that is the difference between means of the treatment and comparison groups (Lauer and Asher 1988; Glass and Hopkins 1984). In this study, effect size refers to a gain effect size that is calculated by subtracting the difference between the means of the pretest and posttest of the comparison group from the difference between the means of the pretest and posttest of the treatment group, and dividing this difference by the pooled standard deviation (square root of the mean square between subjects). A t-test of independence was calculated on the pretest scores to check for evidence of group equivalency.

The XL random number generator was used to randomly generate one focus group of 12 students from the comparison group and one from the treatment group; these groups were interviewed separately. All students were willing participants, and those selected attended the interviews. Students were asked (a) why they were taking this physical science course, (b) how important it was for them to receive a good grade in the course, (c) how motivated they were to learn the content in the course, (d) what obstacles they experienced when they tried to study, (e) what effects completing the log of study hours outside of class had on their study protocol, (f) what effects completing the ARFTS had on their study protocol, (g) to describe a typical day, (h) to describe a weekend, (i) to describe what type of instructor they prefer to learn from, and; to comment on any other concerns they may have.

Results

The results of this pilot study consist of a quantitative part and a qualitative part. Table 1 summarizes the descriptive analysis of the study. In Figure 1, the time-treatment interaction shows the treatment group made a greater increase in achievement than the comparison group. The difference in mean gain scores between the treatment and comparison groups is 2.75. The obtained F value, 3.08 (p = 0.085), indicates the difference is significant. The effect size, 0.49, shows the average gain score of the treatment group exceeds 69% of the gain scores of the comparison group.

$$\text{Effect size} = \frac{M1-M2}{\sqrt{\frac{s1^2\times(n1-1)+s2^2\times(n2-1)}{n1+n2-2}}} = \frac{11.92-9.15}{\sqrt{\frac{6.00^2\times(36-1)+4.97^2\times(20-1)}{36+20-2}}} = 0.49$$

Reliability analysis conducted on students' responses for the 48 multiple-choice questions of the physical science posttest shows the Cronbach's alpha (a measure of internal consistency, homogeneity of test items) at 0.78.

Most students attributed their successes or failures to effort or lack of effort, respectively. None attributed their successes to ability, or their failures to lack of ability. Some attributed their failures to test difficulty, to the test being too long, or to test questions being different from the questions they had received in class. Some attributed their failures to work, other exams, lack of sleep, or child care. Students who stated they were successful on the test stated that they had studied, did their assignments, read over their notes, did problems over again, and the like. Students who stated that they were unsuccessful said that they had not studied, kept up with assignments, read their notes, or did problems over again.

Those who were successful stated that they would continue using the strategies that they had used for this test to prepare for the next test. Those who were unsuccessful stated they would change their strategies in one or more of the following ways: They would study more, do the assignments, redo some of the problems, and the like. Following up on a sample of students who had been successful showed that they had, indeed, continued the strategies that resulted in success. Those who had been unsuccessful changed their strategies and became successful; then, they continued with these strategies and were successful on the following tests. A few, however, remained unsuccessful—although they stated that they would change study strategies, they did not. Others stated that even though they studied more, they still didn't understand the material. Ninety percent of the participants submitted two or three ARFTS, 5% submitted one, and 5% submitted all four. Turning in the

FIGURE 2

Attributional rating form for test scores.

Name______________________________

Score on test__________________________

My test score is a ❑ success ❑ nonsuccess

The reasons I received this score include

1.
2.
3.
4.

How I prepared for this test

1.
2.
3.
4.

This is what I plan to do next time

1.
2.
3.
4.

This form is adapted from the one in Alderman, M.K. 2004. *Motivation for achievement: Possibilities for teaching and learning,* p. 39. Mahwah, NJ: Lawrence Erlbaum.

logs of study hours outside of class diminished continuously after the first week, so much so that by the end of the semester very few participants turned in their logs—no pattern could be determined.

Interview

To the question regarding the reason they were taking the course in physical science, students in both focus groups responded unanimously that it was because it was a core course requirement of their major—they were "forced" to take it. In general, taking these courses was not meaningful: They saw no connection to their major, they felt little motivation to do well in the course—just well enough to receive a passing grade. In addition, completing the log of study hours outside of class did not motivate them to study. The treatment group, however, did state that the ARFTS was helpful in that it made them think about and assess what they did to prepare for an examination.

When asked to describe the characteristics of the instructor they would prefer, they responded as follows: They preferred an instructor who was knowledgeable and who could relate to them. They further stated that they would be more interested in learning the concepts if the instructor would make the course meaningful (in their case, useful) to their lives. And they preferred instruction that explained content more conceptually rather than mathematically with strings of formulae.

Students' marital statuses ranged from single, to single with children, to married. Most of them worked full time. Relatively little time and effort were put into the course because they did not see how it related to their major, so if events occurred that made study time scarce, the physical science class was the one that received the least attention. Specifically, if a single mother's children became ill, she sacrificed the time she had budgeted for the physical science course. In some cases, there seemed to be little, if any, time to spend on the physical science course after work and domestic duties had been fulfilled. Some of the single males did not study on the weekends at all.

Discussion

This pilot study applied attribution theory to undergraduate nonscience majors taking physical science courses to determine to what these students attributed their successes or failures on each four unit tests throughout one semester; what strategies they planned to use in preparing for the next unit test; and whether their own monitoring of test results, through completing the ARFTS, would increase their achievement in the physical science courses.

The most common attribution given to either successes or failures was effort or lack of effort, respectively—a finding consistent with the literature. That students attributed neither success nor failure to ability or lack of ability, respectively, likely indicates that the students, in general, do not perceive the task as being especially difficult. Several who viewed their test scores as being unsuccessful, notwithstanding that the scores were a pass, planned to change their strategies (for example, to study more), but did not follow through—they did not seem motivated to increase their scores further. Indeed, in the interview, the majority of students asserted that they only put in the minimum amount of effort required to achieve a passing grade.

Nonetheless, the treatment group outperformed the comparison group. The effect size of 0.49, which translates to the average gain score of the treatment group exceeding 69% of the gain scores of the comparison group, speaks well for the practice of having students complete the ARFTS, specifically, having them evaluate their own performance, think of reasons for this performance, and decide what they will do about it. This procedure likely gave students a sense of direction, and putting their plans in writing seemed to motivate them to carry through with their commitment. This outcome is consistent with the literature that shows that attribute training can increase achievement. And although attribute training, per se, did not take place in this study, it is still similar to studies in which it did take place in that students were required to evaluate their performances and to think about the reasons for their successes or failures and plan steps to make them successful.

In addition to attribution theory, the interviews revealed several important student concerns regarding motivation, interest, and meaningfulness. Motivation is the sine qua non for achievement, and students pointed out two strategies that would motivate them to learn: make the classes interesting and make the content meaningful. Interest can be maintained by introducing variety in instruction, and meaningfulness by relating the concepts taught to events that occur in students' lives. This pilot study provides good evidence that applying attribution theory can increase the achievement of nonscience majors taking physical science courses. Based on the promising results of this study, the authors have begun a second study on a broader scale: more faculty and more groups. They have improved this second study by adding an attribution training component, and by following up the treatment groups in subsequent courses to see whether they continue to analyze their performances, alter their learning strategies, and show greater achievement than those who have not received this training.

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G. Herold Poelzer (hpoelzer@utpa.edu) *is a professor in the Department of Educational Psychology and* ***Liang Zeng*** (zengl@utpa.edu) *is an associate professor in the Department of Physics and Geology at the University of Texas-Pan American in Edinburg, Texas.*