International Journal of Research in Social Sciences & Humanities http://www.ijrssh.com/

(IJRSSH) 2012, Vol. No. 2, Issue No. I, Jul-Sep ISSN: 2249-4642

STUDY ON ACHIEVEMENT-RELATED BELIEFS OF WOMEN IN ENGINEERING, INCLUDING BELIEFS ABOUT THE NATURE OF ABILITIES

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ABSTRACT

The purpose of this study is to test a theoretical causal model concerning how elementary and secondary school principals can influence school student achievement through the frequency of implementation of certain instructional leadership behaviors. After controlling for contextual variables, we hypothesized that three latent variables related to principal instructional leadership (school governance, instructional organization, school climate) affected student achievement. A total of 332 teachers and 56 school principals participated in the study. We conducted separate analyses of the proposed model at the individual and school level. The results confirm that the proposed model fit the data. We discuss the theoretical and practical implications of the results.

INTRODUCTION

Schools, now more than ever, are challenged to improve to the extent that every effort is made to ensure the success of all students (No Child Left behind (NCLB); Maryland State Department of Education, 2003). In the state where this study was conducted, the state department of education has for a number of years=instituted school reform initiatives where individual schools are held accountable for student achievement. Under the provisions of the School Improvement Act, the state was authorized to takeaction that included reassignment/dismissal of the principal and/or placing the school in reconstitution and ultimately under a private or charter contractor (Hall, Wiener, & Carey, 2003). The passage of the NoChild Left Behind Act gave federal leverage to the states in their school reform policies, primarily because of the threat of the loss of federal funds to support the implementation of programs for school improvement.

Action by the state in this study is defined as restructuring, a process that begins by identifying schools that are not making adequate progress as measured by a series of state assessments and attendance rates. Schools under local restructuring are given additional assistance from the state and are directed to developannual school improvement plans. They are then monitored by the state for several years to check on progress made in each school. Only when it is apparent that school improvement is inadequate does the state move toward reconstitution and state take-over. Placed at high risk as a result of these actions is the school principal. Efforts to improve education relate directly to the quality of leadership provided in the schools.

Leadership

There are various models or methods to capture information concerning leadership roles and styles (Cohen et al., 1972; Mintzberg, 1980; Schein, 1984; Yukl, 1989). For example, Sebring and Bryk (2000) posit that "the behaviors and practices of the principal have influence on all aspects of the learning community, which leads to school success" (p.441). They state that the specifics of leadership are not just a listing of the correlates of effective schools; the specifics include behavior and practices related to five domains: Vision, Mission, Culture, Curriculum and Classroom Instruction. They further state that the vision of the principal, the mission of the school and the culture of the organization cannot be separated; one supports and affects the other. Curriculum and Classroom Instruction are critical to student achievement. Promoting student learning is a priority for successful principals. These researchers conclude that as principals perform as instructional leaders, they create an environment for learning, set high standards for teaching and allow teachers to take risks and try new methods of teaching (Sebring & Bryk, 2000).

Following his research on principals and empowerment in schools, Hughes (2004) designed a model for restructuring schools that included guidelines that used both questions and suggestions. The question format seems to be better suited for those items the principal needs to determine or consider. The suggestion format seems to be more useful for highlighting items that were not fully developed in past practices. Both types of statements reflect the insights of principals in the research study and observationscollected in school visits and conferences.

The guidelines are divided into two categories: Pre-implementation and Implementation. The first category focuses on preexisting conditions and considerations that enhance or inhibit the success of the innovations for school improvement; the second category is composed of factors and considerations that appeared during the course of the innovation.

Pre-implementation Phase:

Autonomy: How much freedom does the school have to make its own decision about curriculum, organization, budget, instructional methods and materials, etc? Early staff involvement: If the innovation is the principal's idea, how quickly can the principal expects "buy-in" from the staff; if the innovation originated with the staff, how will the ideas be nurtured, expanded, implemented? _ Community involvement: When will business leaders and community members be invited to join the planning team and what level of participation can be expected?

Beliefs about the nature of abilities and the meaning of difficulties. To examine beliefs about the nature of an aptitude for engineering, participants were asked to rate their levels of agreement with the following two statements: (a) "You have a certain amount of aptitude for engineering, and you really can't do much to change it"; and (b) "You can learn new things, but you can't really change your basic aptitude for engineering." Participants rated their agreement on scales ranging from 1 (*strongly agree*) to 6 (*strongly disagree*). Consistent with other research examining entity and incremental beliefs (e.g., Levy & Dweck, 1999) responses were averaged, and participants whose averages were above 3.5 (indicating a tendency to disagree with the statements) were classified as having an incremental theory of aptitude for engineering. Those whose average scores were below 3.5 were classified as having an entity theory of aptitude for engineering. Participants whose scores were exactly 3.5 were excluded from all analyses that included the entity-incremental distinction. An analogous pair of questions was included to assess beliefs about general intelligence. These questions were identical, except that the phrase *basic intelligence* replaced the phrase *aptitude for engineering*. Responses were scored in the same way, with each participant being classified as having an incremental theory of intelligence or an entity theory of intelligence (except for those whose average responses were 3.5, who were excluded from all analyses that included this distinction).

To examine responses to difficulty, participants were asked to recall a time when they had difficulty in a college course and to describe the difficulty. They were asked to select from a set of forced-choice options to describe how they had responded to the difficulty: They dropped the class, worked less hard, worked about the same amount, or worked harder.

Perceptions of whether gender affects treatment. Two measures were used to examine students' perceptions of possible gender differences in how engineering students are treated. One measure asked students whether they believed that male and female students in their major were treated differently. The second measure asked students to rate their levels of agreement *Gender and Beliefs* with the statement "The climate women face in engineering is no different from the climate faced by men." Participants rated their agreement on a forced-choice scale ranging from 1 (*strongly agree*) to 6 (*strongly disagree*).To assess whether men and women in engineering differed in the extent to which they viewed their interests as being a good fit with their majors, they were asked, "To what extent do you think this major is a good match to your interests?" The scale ranged from 1 (*not at all*) to 5 (*perfect*). To assess students' weighting of particular factors in their careers, they were instructed, "Rate the importance to your career of each of the following, from 1 (not at all important) to 5 (essential)." All categories for which multiple items were used were averaged to form a single scale. The following items assessed the importance of extrinsic factors: "making enough money to live comfortably," "the opportunity to make a large amount of money," and "a prestigious occupation." The following items assessed the importance of intrinsic factors: "working on interesting projects" and "the opportunity to learn new things." Additional items included "having a flexible schedule" and "making a contribution to society."

RESULTS

Beliefs about the Nature of Abilities and the Interpretation of Difficulties:

One goal of the present research was to determine whether female engineering students would show a greater tendency than their male counterparts to endorse entity (fixed) views of engineering aptitude. This was indeed the case: Of participants who endorsed either entity or incremental beliefs (i.e., their scores were above or below 3.5, the midpoint of the scale), 72% of female engineering students were classified as holding entity theories of aptitude for engineering, as compared to 46% of male engineering students, $\chi 2(1, n = 125) = 6.28, p < .05$. In contrast, no such gender differences were seen concerning more general beliefs about intelligence, with both male and female engineering students endorsing entity views of intelligence about half of the time. Table 1 shows the percentage of participants who endorsed entity beliefs about engineering aptitude and intelligence by gender and major. Of the women who reported dropping a class in the face of difficulty, 100% also endorsed entity beliefs about engineering aptitude. In contrast, among women who did not report drop-

Table1. Percentage of Participants Who Endorsed Entity Beliefs Concerning Engineering Aptitude and Intelligence, by Gender and Major Women Men.

	MEN		WOMEN	
	E	NE	E	NE
Engineering	73	38	46	60

aptitude				
Intelligence	50	35	46	45

*Gail D. Heyman et al.*ping a class in the face of difficulty, 61% endorsed entity beliefs about engineering aptitude, $\chi 2(1, n = 32) = 4.90$, $p < .05$. No such relation between beliefs about engineering aptitude and having dropped a course in the face of difficulty was seen among the male engineering students.1 Perceptions of Whether Gender Affects Treatment Another goal of the present study was to determine the extent to which women might perceive differences in how male and female engineering students are treated. Just over half (55%) of female engineering majors perceived gender differences in how engineering students are treated, as compared to only about a quarter (27%) of their male counterparts, $\chi 2(1, n = 137) = 9.03$, $p < .005$. Among participants in nonengineering majors, only 12% of women and 17% of men said that men and women in their majors were treated differently, a difference that did not reach significance. This suggests that the gender differences in the perceived treatment of engineering students cannot be explained simply in terms of a general tendency for women to perceive differential treatment. In a second measure of perceptions of differential treatment, participants were asked to rate their levels of agreement with the statement "The climate women face in engineering is no different from the climate faced by men" (on a scale ranging from 1 to 6, with 6 indicating strong disagreement). Amongengineering students, women ($M = 4.44$) were significantly more likely than men ($M = 3.45$) to disagree with this statement, $F(1, 133) = 10.32$, $MSE = 2.507$, $p < .005$. Among nonengineering students, women ($M = 4.48$) were also more likely than men ($M = 3.62$) to disagree with this statement, $F(1, 79) = 8.131$, $MSE = 1.694$, $p < .01$. Values and Interests Among engineering majors, women were less likely than men to report that engineering was a good match for their interests on a 5-point scale, M for women = 3.58, M for men = 3.96, $F(1, 139) = 4.864$, $MSE = .771$, $p < .05$. One set of measures investigated whether the values and interests of female engineering students differed from those of women who had chosen nonengineering majors. Data from these measures are presented in Table 2. Two 2 (gender) × 2 (major [engineering, nonengineering]) between-subjects analyses of variance were conducted to determine if there were any significant effects of gender or major on the personal values that were measured. Measuresof intrinsic values (see Table 1) revealed no main effects of gender or major.

However, there was a significant gender-by-major interaction, with women in engineering showing less concern with intrinsic factors than women outside of engineering and the opposite 1One might wonder whether female students reported being more likely to drop a class in the face of difficulty as compared to their male counterparts because of a lack of academic preparedness. To evaluate this possible explanation, participants were asked to report their Scholastic Assessment Test (SAT) math scores and overall grade point averages. Analysis of these data revealed no evidence that reports of dropping a class were related to math ability or overall academic performance. However, SAT math scores did differ as a function of major and gender. Specifically, a 2 (gender [male, female]) × 2 (major [engineering, nonengineering]) between-subjects analysis of variance confirmed that SAT math scores were higher for engineering students than for nonengineering students, as indicated by a significant main effect of major, $F(1, 144) = 14.9$, $MSE = 4510$, $p < .001$. There was also a gender-by major interaction, $F(1, 144)$, $MSE = 4510$, $p < .05$, with SAT math score showing a greater discrepancy across majors for women than for men. An analogous test of grade point average showed no effects of major or gender. *Gender and Beliefs 47* pattern seen for men, $F(1, 231) = 6.494$, $MSE = .433$, $p < .025$. These results suggest that women who place a high value on intrinsic factors may be relatively unlikely to select engineering as a major. Measures of extrinsic value (money and prestige) revealed a different pattern. On this measure, there wasa significant effect of gender, with men giving these factors higher ratings, $F\ (1, 231) = 17.061$, $MSE = 5.427$, $p < .001$. This pattern was consistent with prior research showing that men tend to place higher value on money and prestige in their choices of careers (e.g., Tittle, 1982). There was a nearly significant interaction between major and gender, $F(1, 231) = 3.390$, $MSE = .603$, $p < .07$, with women in engineering giving greater weight to extrinsic factors (i.e., money and prestige) than women outside of engineering and men showing no difference related to major type. The measure of the value of making a contribution to society revealed a significant effect of major, with engineering majors placing less weight on this value than others, $F(1, 231) = 1.142$, $MSE = 5.490$, $p < .01$. There was also a marginallysignificant interaction between major and gender, $F(1, 231) = 3.788$, $MSE = 1.142$, $p < .07$, with women outside of engineering giving greater weight to making a contribution to society than men outside of engineering, but no clear difference between men and women in engineering. The measure of the value ofa flexible schedule showed no significant effects.