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ABSTRACT

This study compared three measures of self-efficacy and assessed the responses of self-efficacy on the basis of A. Bandura's (1997) conceptualization. The responses of 331 undergraduates to a series of inventories yielded three variables descriptive of the self-efficacy process; a causal model of the intercorrelations of these variables was constructed from predictions based on self-efficacy theory. A confirmatory factor analysis indicated that the self-efficacy measures of science, mathematics, and self-regulated learning exhibited discriminant validity. (Contains 6 tables, 2 figures, and 27 references.) (Author/SLD)

Discriminant Validity of Self-Efficacy Measures

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Author's Notes

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Abstract

The study compared 3 measures of self-efficacy and assessed the responses of self-efficacy on the basis of A. Bandura's (1977) conceptulatization. The responses of 331 undergraduates to a series of inventories yielded three variables descriptive of self-efficacy process; a causal model of the intercorrelations of these variables was constructed from predictions based on self-efficacy theory. A confirmatory factor analysis indicated that the self-efficacy measures of science, mathematics, and self-regulated learning exhibited discriminant validity.

Discriminant Validity of Self-Efficacy Measures

When Bandura (1977) proposed the theoretical framework to help explain and predict human behavior, he suggested that behavior in most situations is mediated by *self-efficacy* expectations (i.e., beliefs about one's capacities to perform successfully a given task or behavior). Much of the early research concerning self-efficacy theory centered on the clinical problems of phobias (e. g., Bandura, Adams, Hardy, & Howells, 1980). The results showed that changes in self-efficacy are associated with changes in behavior and that self-efficacy predicts the outcome of a therapy. Researchers have expanded the investigation to important influences on behavior in weight loss (e. g. Edell, Edington, Herd, O'Brien, & Witkin, 1987), social interactions (e. g., Fichten, Bourdon, Amsel, & Fox, 1987), teaching performance (e. g., Gibson & Dembo, 1984), academic achievement (e. g., Schunk, 1987), and career decision-making (e. g. Taylor & Betz, 1983). Findings from such research across domains have supported the explanatory and predictive power of self-efficacy theory.

The methodological utility of self-efficacy theory is assessed by using reliability and validity of the self-efficacy measures based upon the four sources of information through which self-efficacy expectations are learned and by which they can be modified, as specified by Bandura (1977). Bandura viewed anxiety as a *coeffect* of self-efficacy expectations in that the level of anxiety is seen to covary inversely with the level and strength of expectations (I. e., as self-efficacy expectations are increased, anxiety should decrease and vice versa). Development of such self-efficacy measures is difficult because self-efficacy is highly context or situation dependent. No single standardized measure of self-efficacy will be appropriate for all studies and researchers may need to develop new or significantly revised measures in each investigation (Vispoel & Chen, 1990).

The self-efficacy scales of Bandura (1984) have specificity and are hierarchically arranged. The measurement follows a two-step approach: First, a subject notes whether or not he or she can perform the behavior; then, he or she indicates the *strength* of efficacy on a 90-point certainty scale. According to Bandura, the first step assesses the *magnitude* of self-efficacy by summing the number of "can-do" assertions. However, Owen and Froman (1988) have proposed an alternative approach to measuring magnitude by indicating the level of task in the hierarchy where a person first claims "cannot-do" while also asserting that any measurement of magnitude may be flawed if "can-do" is modified by weak certainty in the second step.

The strength and magnitude may *sound* like different aspects of self-efficacy and Cervone (1987) continues to promote the conceptual differences. The strict empirical approach of whether the two measures give unique and useful information about expectations or behavior has been asked by Wood and Locke (1987). Their research showed the two scales have a substantial overlap (correlations of 0.64 to 0.67 between strength and magnitude estimates). Lee (1984) reported a correlation of 0.83 between strength and magnitude scales of assertiveness while Fichten, Bourdon, Amsel, and Fox (1987) found a correlation of 0.95 between the measures. Both decided to drop the *strength* data from the rest of their research. To be succinct, strength and magnitude are redundant and if using regression procedures, the estimates will be biased because of multicollinearity.

Other researchers have developed their own styles of measuring self-efficacy. Most measures are self-report, Likert-type scales. While reliability estimates are described infrequently in the literature and when reported are usually obtained and computed easily (i.e., Coefficient Alphas), the research is lacking in those that might provide the most compelling and appropriate evidence of score consistency (i. e., equivalent forms, test-retest). While the reliability data for self-efficacy measures is modest, the validity data are even more limited (Vispoel & Chen, 1990). Construct validity sources were usually correlations with other measures and reported group differences. The validity of the measures often was assumed rather than systematically evaluated.

Another methodological problem of self-efficacy is between performance expectations and outcome expectations. Bandura (1986) stresses the difference between performance expectations (self-efficacy beliefs) and outcome expectations. Some researchers disregard the distinction and build complex items that envelop both tenets. Such an instance is as follows: "When a student gets a better grade than he usually gets, it is usually because I found better ways of teaching that student" (Gibson & Dembo, 1984). Then there are other situations where the idea that self-efficacy beliefs refer to relatively circumscribed behaviors and develop massive questions: "How confident are you?", "How persistent are you?" (Englert & Tomlinson-Keasey, 1986); "I feel that I am making a significant difference in the lives of my students" (Hoover-Dempsey, Bassler, & Brissie, 1987); "If parents would do more with their children, I could do more" (Gibson & Dembo, 1984). There are also a few researchers who use items that are outcome beliefs and choose to call them self-efficacy questions (e.g., Ashton & Webb, 1986).

The shortcoming in the many existent measures of self-efficacy is the use of potentially inappropriate scale formats, inadequate normative data, and limited evidence of test score reliability and validity. With the available measurements, it appears unlikely that self-efficacy can penetrate clearly and the literature on self-efficacy is beginning to show the predictable blemishes of sloppy measurement. As stated by Owen and Froman (1988, p.4), "Researchers, editors, reviewers, and readers untrained in measurement promote an ambiguous literature that can do great damage to a promising theory. They also elevate worthless constructs to a high (if temporary) station."

When researchers wish to develop a self-efficacy measure, the proper instrument development must validate a given scale on the population of study. The researchers need to validate the self-efficacy measure that could be used to investigate the proposed relationship between efficacy and the outcome or behavioral change. Solberg, O'Brien, Villareal, Kennel, and Davis (1993) proposed to use a college self-efficacy instrument with Hispanic populations after performing construct validation because their study was to validate a college self-efficacy measure that could be used to investigate the proposed relationship between efficacy and college adjustment. In addition to construct validation and reliability estimation, convergent and discriminant validity need to be assessed for the self-efficacy instrument that the researchers are using in the study. Only by these methods will the body of literature turn away from measurements that are so causal and confounded.

The purpose of this investigation is to by Confirmatory Factor Analysis (CFA) examine the discriminant validity between three particular self-efficacy measures. The study used three different self-efficacy measures, with college students as subjects. Thus, the question to be answered was: Do college students have a distinct self-efficacy for science separate from one's mathematics self-efficacy and self-efficacy for self-regulated learning?

Method

Sample and Procedure

Participants (N = 331) were predominantly first- and second-year undergraduates attending a major private university in Los Angeles, California. There were 151 women and 180 men. The distribution of age was 24 at seventeen years and under, 108 at eighteen years, 88 at 19 years, 50 at twenty years, and 61 at twenty-one and older. Students were asked to participate voluntarily in a study on personal confidence to perform everyday science tasks. Individuals who agreed to participate (approximately 90% of all the students) completed the questionnaire packet during one class session of the third or fourth week of the semester. Approximately 48% of the sample were white, non-Hispanic; 20% of the sample were Asian or Pacific Islander; 13% were black, non-Hispanic; 12% were Hispanic; 4% were Native American; and 2% were non-Resident alien. The college major for women was approximately 50% *not either mathematics or science oriented*, 27% *biological science oriented*, 19% *mathematics oriented*, and 4% *physical science oriented.* For men, the college major was 44% *not either mathematics or science oriented*, 40% *mathematics oriented*, 9% *biological science oriented*, and 6% *physical science oriented.* Approximately 49% have a GPA above 3.0 and 93% have a GPA of 2.1 and above.

Measures

Science Profile. The subject's general information and science experiences were characterized in this questionnaire. Subjects were asked to provide demographic information including age, gender, ethnicity, class level at the university, college major, and overall GPA. Biological science was defined on the profile as classes such as biology and psychology. Physical science was defined as classes in chemistry, engineering, astronomy, geology, and physics. The mathematics classes examples were mathematics, business, and computer science.

Science Self-Efficacy Scale. The investigation of science self-efficacy necessitated the development of a measure of self-effiecacy expectations with regard to science. Development of this meausre commenced with a specification of the *domain* of science-related behaviors analogous to the identified behaviors in mathematics by Betz and Hackett (1983). Identified domains were solving science problems, science behaviors used in everyday life, and capability of satisfactory performance in college courses requiring various degress of science knowledge and mastery. Therefore, self-efficacy expectations with regard to science were operationally defined to include perceptions of performance capabiity in relationship to science problems, everyday science tasks, and science-related college coursework.

The Science Self-Efficacy Scale (SSES), developed by Kennedy (1995), contained 60-items identified as relevant to the study of science-related self-efficacy expectancies. The scale was composed of two subscales: (a) the science tasks subscale, consisting of 40 items involving *everyday* science tasks (e.g. brewing a pot of coffee); and (b) the science courses subscale, consisting of 20 science-related college courses. The items of both subscales were rated using a 5-point Likert-type scale which ranged from *no confidence at all* (1) to *complete confidence* (5). For the science tasks subscale, the subjects rated their confidence in their ability to perform successfully the task. For the science courses subscale, the subjects were instructed to rate their confidence in their ability to complete each course with a grade of B or better.

The scale was administered to a development sample of 86 undergraduate students. The results of item analyses demonstrated that no items needed to be removed from the scale. The final version of the Science Self-Effiecacy Scale consisted of 20 science tasks, 20 science problems, and 20 science-related college courses. or a total of 60 items. Total scores were calculated for the science tasks, science problems, and science courses subscales separately and for the 60-item total scale.

Mathematics Self-Efficacy Scale. The Mathematics Self-Efficacy Scale (MSES), developed by Hackett and Betz (1982), has been revised to contain 34 items identified as relevant to the study of math-related self-efficacy expectations (Betz & Hackett, 1993). The scale was composed of two subscales: (a) the math tasks subscale, consisting of 18 items involving *everyday* math tasks (e. g., computing gas mileage); and (b) the math courses subscale, consisting of 16 math-related college courses. On the math tasks, the subjects rated their confidence in their ability to effectively perform the task by using a 5-point Likert-type scale from *no confidence at all* (1) to *complete confidence* (5). On the courses subscale, the subjects were instructed to rate their confidence in their ability to complete each course with a grade of B or better using the same 5-point range.

Self-Efficacy for Self-Regulated Learning. The Self-Efficacy for Self-Regulated Learning Scale (SESRL), originally developed by Bandura (1989b), contained eleven questions (Zimmerman, Bandura, & Martinez-Pons, 1992). The questions measured the students' perceived capability to use a variety of self-regulated learning strategies. The subjects rated their confidence in their ability to successfully perform the self-regulated task by using a 5-point Likert-type scale from *no confidence at all* (1) to *complete confidence* (5).

Results

Summary of Observed Variables

Means and standard deviations of the observed variables are summarized in Table 1. By inspection of Table I, the following observations are noteworthy. The mean scores for Mathematics Self-Efficacy Part I and Part II were higher than those of Science Self-Efficacy Part I and Part II. By comparison, Self-Efficacy for Self-Regulated Learning mean scores were higher than for Science Self-Efficacy while a comparison to Mathematics Self-Efficacy showed more equitability.

Internal-Consistency Reliability of Measures

The internal-consistency reliabilities, α, are shown in Table 2. The reliabilities on total scales for all measures were above 0.90. These high reliability values indicated internal consistency across items and that the measures accurately differentiate individuals. These results indicated that at least 90% of the variance of the total scores were reliable, and 10% was due to measurement error.

The reliability values decreased when the various subscales were analyzed. The Science Self-Efficacy Scale Part I-A and Part I-B respectively decreased to 0.88 and 0.87. Part I-A of the Mathematics Self-Efficacy Scale measured at 0.83 while 0.88 was the result for Part I-B. In the analysis of the Self-Efficacy for Self-Regulated Learning Scale, Part III was 0.88 and Part II was 0.72. These alphas were below 0.90 but above 0.60 and therefore still acceptable for research purposes. No alphas were below the 0.60 level. The source of measurement errors captured was in part due to item selection.

Discriminant Validity of Self-Efficacy Measures

After the reliability analysis, a Confirmatory Factor Analysis (CFA) was conducted on the data collected. This investigation allowed for an assessment for the discriminant validity of the self-efficacy measures. The CFA included an examination of the associations (correlations) between latent factors and between the measured variables and latent factors. The correlation matrix for the CFA model for the science self-efficacy and mathematics self-efficacy measures are shown in Table 3. Table 4 includes the correlations of self-efficacy for self-regulated learning measure with those of science self-efficacy and mathematics self-efficacy.

Table 5 contains the model fit indexes for the one factor, two factor, and three factor models based upon the self-efficacy measures of science, mathematics, and self-regulated learning. The one factor model assumed that the self-efficacy measures were assessing the same construct. The two factor model was designed to assess the association that exists between science self-efficacy and mathematics self-efficacy since these academic domains demonstrate interrelated characterisitcs. Finally, the third model was formulated to address the nexus between the self-efficacy measures of science, mathematics, and self-regulated learning. These correlations were attributed to the similarity in the measurement tools used for the three variables. The comparative fit index (CFI) indicated the amount of covariation in the data captured by the hypothesized model and was adjusted for sample size (Bentler, 1993).

The modifications from Initial CFA to Final CFA for both the two factor and three factor models were correlation of errors between Math Self-Efficacy Part II and Science Self-Efficacy Part II. These portions of the measurements evaluate college course that share interrelated characteristics. Based upon these modifications, the comparative fit index increased from 0.65 to 0.97 in the two factor model and from 0.71 to 0.97 in the three factor model.

An alternative means of assessing the adequacy of the overall fit of the model is the ratio of chi square to degrees of freedom. By utilizing the modifications, the ratio of chi square to degrees of freedom changed from 93.0 to 12.3 for the two factor model and from 46.5 to 7.2 for the three factor model. These statistics show that the data were not a perfect fit but were adequate, according to several criteria. The fit indexes were within the acceptable range (greater than 0.90) and support construction of the structural model.

The standardized CFA loadings and residuals for the CFA model for the two factor model are presented in Figure 1. The loadings and residuals for the three factor model are shown in Figure 2. The loadings on the measured variables were all significant, demonstrating that the measured variables reflected the latent constructs.

Table 6 presents the intercorrelations between latent constructs for the final CFA model for both the two factor model of science self-efficacy and math self-efficacy and the three factor model factor model which includes self-efficacy for self-regulated learning with science and math self-efficacy. These values were used to investigate discriminant validity.

To be able to discuss discriminant validity, the intercorrelation between the latent constructs must be less than the criterion value of 0.90 (Bollen, 1989). For the two factor model, the intercorrelation between science self-efficacy and math self-efficacy was 0.59 which is less than 0.90. This value indicated that the methods exhibited divergence to measure science self-efficacy and math self-efficacy as two discrete constructs. In the three factor model, the intercorrelations of the latent construct were all less than 0.90. These values indicated that the methods exhibited divergence to measure science self-efficacy, math self-efficacy, and self-efficacy for self-regulated learning as three disparate constructs.

Discussion

This study was undertaken to investigate the discriminate validity of self-efficacy measures in the academic domains of science, mathematics, and self-regulated learning. It examined differences in the various self-efficacies. The research investigated how the three measured self-efficacies were associated with one another.

The findings of this study suggested that there were differences in the self-efficacies for self-regulated learning, mathematics, and science. Academic self-regulation was reported to be concerned with the degree to which students were metacognitively, motivationally, and behaviorally proactive regulators to their own learning process (Zimmerman, 1986). The research of Zimmerman, Bandura, and Martinez-Pons (1992) showed that self-efficacy for self-regulated learning was a possible measurable construct. In their studies on mathematics self-efficacy, Betz and Hackett (1983) reported that math-related self-efficacy expectations were measurable. The research had shown that math was a "critical filter" (Sells, 1982) for career plans. Based upon these recommendations, mathematics self-efficacy was incorporated into this study. These results suggest that there was a domain specific self-efficacy associated with a specific academic domain. Bandura (1977) reported that efficacy expectation was differentiable from outcome expectation and specific to a particular domain. It was therefore hypothesized that science self-efficacy would be measured to the specific domain of science.

The data from this present study maintained the concept that college students have a distinct self-efficacy for science separate from one's mathematics self-efficacy and self-efficacy for self-regulated learning. The latent construct of self-efficacy for self-regulated learning was shown to be reflected by the three subscales of Part I, Part II, and Part III of the Self-Efficacy for Self-Regulated Learning measure.

Additionally, the present concept was validated by findings from the present study concerning math self-efficacy. The latent construct of mathematics self-efficacy was shown to be described by the three subscales of Part I-A, Part I-B, and Part II which comprise the Mathematics Self-Efficacy Scale.

Concerning science self-efficacy, the data from the present study supported the concept. The three subscales of Part I-A, Part I-B, and Part II of the Science Self-Efficacy Scale were shown to reflect the latent construct of science self-efficacy. It appeared that the domain of science and how a person learns science might be affected by a person's science self-efficacy. Furthermore, it was possible that the choice of science activities, the amount of effort expended in learning science, and the level of persistence in aversive science situations might be determined by the student's science self-efficacy.

The findings of this study indicated that the self-efficacies of science and mathematics were correlated yet discriminantly valid. The examination of method factor correlations reflected on their discriminantability and the extent to which the methods were maximally dissimilar. The correlation of 0.59 was probably explained by the fact that the substantive content of all comparable items in the science and mathematics scales were similarly worded to maximize responses by different students. However, this might not be as substantial an influence as the development of a second-order variable to encompass all of the first-order self-efficacy latents: science, mathematics, and self-regulated learning.

This study's findings may facilitate our understanding in being more able to discriminate students' self-efficacy in a particular academic domain. As a result, the information yielded could contribute to the adjustment of learning to specific academic situations. Students appeared to have distinct self-efficacies to the academic domains of science, mathematics, and self-regulated learning. Differences in students' responses were differentiable and specific to a specific domain (Bandura, 1977).

Limitations and Suggestions

The results observed in the present study need to be qualified by the study's limitations. First, the data obtained for the study were drawn from a single institution. The consequence of this is that the ability to generalize results from this study to other academic domains is limited. A suggestion is the need for replication with students from other institutions.

Finally, limitations of the measures used in this study are noteworthy. All scales used in this study relied on participants' self-reports requiring perceptions of one's ability to perform in a specified domain. The internal and external validity of the measures is limited to this study. The development of more complete and psychometrically sound measures of self-efficacy in specified academic domains is warranted and would strengthen future investigations of discriminant validity within self-efficacy.

Conclusion

The measure developed herein, while in need of further evaluative research, is advanced for utilization to assess a general index of the strength of science self-efficacy expectations and information concerning the individual's degree of confidence with respect to each of the science-related tasks or behaviors. With the behavioral specificity of the information yielded, intervention strategies may be designed to incorporate a focus on increasing self-efficacy expectations with respect to those specific behaviors and thereby should generalize to other science-related behaviors. The intervention strategies should focus on providing experiences relevant to the *strengthening* of science self-efficacy expectations, e. g., performance accomplishments, vicarious learning or modeling, and encouragement and support to engage in new behaviors.

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Table 1

Summary Statistics of Observed Variables: Mean Scale Scores

Variable	Mean	Standard Deviation
Science Self-Efficacy Scale		
Part I: Total	3.85	0.60
Part II: Total	3.12	0.89
Part I-A	3.86	0.64
Part I-B	3.84	0.59
Mathematics Self-Efficacy Scale		
Part I: Total	4.14	0.66
Part II: Total	3.60	0.85
Part I-A	4.20	0.61
Part I-B	4.08	0.74
Self-Efficacy for Self-Regulated Learning Scale		
Total	4.03	0.69
Part I	4.19	0.71
Part II	3.87	0.73
Part III	4.04	0.78

Table 2

Reliability of Measures

Measure	α	Standardized α
Science Self-Efficacy Scale		
Entire Scale	0.95	0.95
Part I	0.93	0.94
Part II	0.96	0.96
Part I-A	0.88	0.88
Part I-B	0.87	0.87
Mathematics Self-Efficacy Scale		
Entire Scale	0.96	0.96
Part I	0.93	0.93
Part II	0.94	0.94
Part I-A	0.83	0.83
Part I-B	0.88	0.88
Self-Efficacy for Self-Regulated Learning		
Entire Scale	0.93	0.93
Part I	0.81	0.82
Part II	0.72	0.72
Part III	0.88	0.89

Table 3

Correlation Matrix: Two Factor Model

		Math Self-Efficacy			Science Self-Efficacy	
		Part I-B	Part I-A	Part II	Part I-B	Part I-A
Math Self-Efficacy	Part I-A	0.90				
	Part II	0.65	0.61			
Science Self-Efficacy	Part I-B	0.54	0.52	0.33		
	Part I-A	0.55	0.52	0.32	0.93	
	Part II	0.51	0.48	0.80	0.41	0.39

Note. All correlation coefficients in this table were significant at 0.001.

Table 4

Correlation Matrix: Three Factor Model

		Math Self-Efficacy			Science Self-Efficacy			Self-Efficacy for Self-Regulated Learning	
		Part I-B	Part I-A	Part II	Part I-B	Part I-A	Part II	Part I	Part II
Math Self-Efficacy	Part I-A	0.90							
	Part II	0.65	0.61						
Science Self-Efficacy	Part I-B	0.54	0.52	0.33					
	Part I-A	0.55	0.52	0.32	0.93				
	Part II	0.51	0.48	0.80	0.41	0.39			
Self-Efficacy for Self-Regulated Learning	Part I	0.34	0.40	0.29	0.34	0.31	0.27		
	Part II	0.44	0.45	0.36	0.43	0.43	0.38	0.73	
	Part III	0.40	0.44	0.34	0.37	0.35	0.32	0.88	0.79

Note. All correlation coefficients in this table were significant at 0.001.

Table 5

Summary of Confirmatory Factor Analysis

Model	X^2	df	p value	Comparative Fit Index
One factor	1235	9	< 0.001	0.58
Two factor				
Initial CFA	1768	19	< 0.001	0.65
Final CFA	86	7	< 0.001	0.97
Three factor				
Initial CFA	1906	41	< 0.001	0.71
Final CFA	165	23	< 0.001	0.97

Table 6

Intercorrelations between Factors for the Final CFA Models

Model	Science Self-Efficacy	Math Self-Efficacy
Two Factor		
Math Self-Efficacy	0.591	
Three Factor		
Math Self-Efficacy	0.591	
Self-Efficacy for Self-Regulated Learning	0.403	0.457

Note. All intercorrelations for this table were significant at the 0.001 level.

Figure Caption

<u>Figure 1.</u> Final CFA model for two factors, Science Self-Efficacy and Math Self-Efficacy. Correlations between factors and loadings between factors and the variables they predict are presented. (Large circles represent latent constructs, rectangles are measured variables, and small circles with numbers are residual variances. Factor loadings are standardized and significant correlations were determined by critical ratios on unstandardized coefficients. [*All coefficients in this model significant at 0.001].)

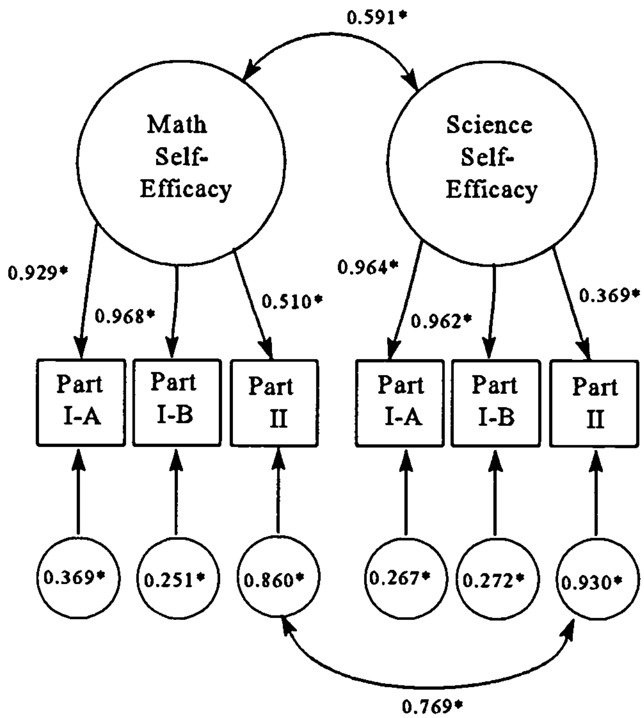
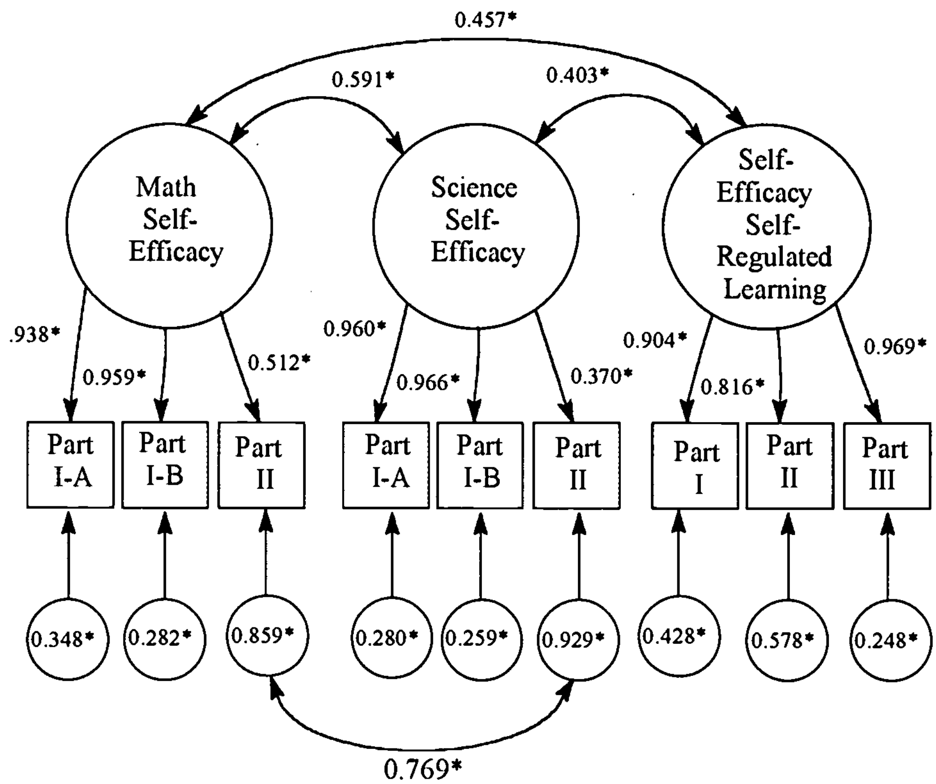

0.591*
Math Self-Efficacy
Science Self-Efficacy
0.929*
0.968*
0.510*
0.964*
0.962*
0.369*
Part I-A
Part I-B
Part II
Part I-A
Part I-B
Part II
0.369*
0.251*
0.860*
0.267*
0.272*
0.930*
0.769*

Figure Caption

Figure 2. Final CFA model for three factors, Science Self-Efficacy, Math Self-Efficacy, and Self-Efficacy for Self-Regulated Learning. Correlations between factors and loadings between factors and the variables they predict are presented. (Large circles represent latent constructs, rectangles are measured variables, and small circles with numbers are residual variances. Factor loadings are standardized and significant correlations were determined by critical ratios on unstandardized coefficients. [*All coefficients in this model significant at 0.001].)



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