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Effects of selected affective variables on mathematics achievement of freshmen science and engineering students: The case of Hawassa University

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ABSTRACT

This study was conducted mainly to determine the direct and indirect effects of affective variables on mathematics achievement of freshman science and engineering students of Hawassa University. Descriptive survey data were obtained from 245 (201 male, 44 female) students from five departments of science and engineering faculties. Data were acquired through adopted instruments for measuring mathematics self-efficacy and attitudes towards mathematics. Cronbach's α was obtained for checking reliability of reduced factors. The t-test was employed to compare means; path analysis procedures were used to analyze direct and indirect effects of gender and affective variables on mathematics achievement scores. The results show that the factor structures of self-efficacy and attitude variables were more or less in agreement with the literature; the level of attitudes towards mathematics and mathematics self-efficacy are moderate for the study groups; more specifically, students' motivation towards mathematics was just below average; both confidence in mathematics and enjoying doing mathematics were marginally high. On the other hand, students have high scores in valuing mathematics and high problem solving self-efficacy and engagement in mathematics self-efficacy. Some attitude subscales and all self-efficacy subscales were highly correlated with mathematics achievement. Results depict that there is significant gender difference in mathematics achievement and only in two of self-efficacy subscales, mathematics capability self-efficacy and engagement in mathematics self-efficacy. Although the amount of variance in mathematics achievement explained by the motivational variables is low, the direct effects of gender and the self-efficacy variables on mathematics achievement were significant at 0.05 level of significance; and confidence in doing mathematics showed significant indirect effect on mathematics achievement. It seems that the self-efficacy variables contribute direct effects on mathematics achievement while the attitude variables have indirect effects through the self-efficacy variables and possibly other predictors not included in the model. Recommendations were forwarded for teaching personnel in the area of mathematics and engineering, academic departments, and the university administration with regard to the necessary supports to girls and marginally performing students.

Keywords: Mathematics achievement, mathematics self-efficacy, mathematics attitudes, path analysis, direct and indirect effects.

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INTRODUCTION

Several mathematics courses are compulsory in all programs of science and engineering students in higher education institutions. The justification for teaching mathematics at college level education in science and engineering fields is to enable students to handle, use, and interpret quantitative relationships of variables and deal with data in research in their own fields of study. Mathematical knowledge and reasoning skills prepare students to deal effectively with analytical and statistical tasks of the world of work. Although instructors of mathematics courses put a lot of efforts to simplify the subject, freshmen students usually face considerable difficulties in doing the courses (Bandura et al., 2001; Tobias, 1995). Our experience also shows that these difficulties are prevalent in our university students at Hawassa.

Attitudinal research in the field of mathematics has dealt almost exclusively with anxiety or enjoyment of subject matter, excluding other factors (Tapia and Marsh, 2004a). Cognitive factors (such as mathematics aptitude, mathematics background and cognitive dimensions of attitudes towards mathematics) and affective factors (such as mathematics self-efficacy, mathematics anxiety, motivation, and affective dimensions of attitudes towards mathematics) are some of the variables considered to be related to the difficulty or ease students experience in doing mathematics courses and performing mathematics related tasks (Haycock and Steen, 2002; Pajares and Miller, 1995; Pajares and Kranzler, 1995; Pajares and Miller, 1994; Cretchley, 2008; Carmichael and Taylor, 2005; Bandura, 2005). Hence, these variables seem to be related to engagement and performance in college mathematics. The purpose of this study is to assess the impacts of the affective variables (mathematics self-efficacy, mathematics attitudes, and motivation) on mathematics performance of freshmen science and engineering students. In other words the study aims to investigate the extent to what these variables directly or indirectly explain mathematics achievement of freshmen science and engineering pre-service students in calculus courses.

Statement of the problem

Even though it has been recognized that affective variables may have long-term effects on the students' use of the knowledge acquired in the classroom, mathematics educators and researchers have primarily focused on cognitive skills and knowledge paying less attention to non-cognitive factors such as beliefs, attitudes, motivations and feelings (Gal and Ginsberg, 1994). It is important to examine the structure of achievement in mathematics in this population because, first, research on the subject using data from home institutions is sporadic. That is, the existing relationships of affective variables underlying achievement in mathematics are not yet tested using data drawn from local context. While there are overarching similarities concerning the acquisition of mathematics skills, researchers have shown that children's mathematical abilities differ across cultures and countries. For example, researchers have conducted thorough comparisons between countries, and have determined that in countries such as Taiwan and Japan, parents place more emphasis on effort rather than one's innate intellectual ability in school success. Moreover, parents in these countries tend to set higher expectations and standards for their children. In turn, students spend more time on homework and value homework more than American and Canadian children (Klassen, 2004; Stevenson et al., 1986).

Secondly, studying mathematics performance of pre-service science and engineering students is of particular importance because as students of science and engineering they pass through computational and technical courses that draw on mathematical and statistical skills and knowledge, and later as scientists they will be expected to instill positive thinking about mathematics and its applications in their clients and students. In turn engaging students of science and engineering in doing mathematics takes some understanding of how the affective variables operate for males and females in learning mathematics. Moreover, the study is significant since it may shed light on the structure of achievement in mathematics among freshmen population given the existing conditions of cognitive and affective preparations of the in-coming freshmen students.

Objectives of the study

The study aimed to:

1. Determine the factor structures of the affective variables of the study using current data.
2. Survey the prevalence and correlates of the affective variables among the study groups.
3. Summarize from data the correlation between and within the affective and achievement variables of the study.
4. Determine the amount of variance in mathematics achievement explained by the affective variables independently as well as collectively.
5. Test gender difference in the study variables.
6. Determine the direct and indirect effects of gender, mathematics attitudes and self- efficacy variables on students' mathematics achievement.

Research questions

The study attempted to answer the following basic research questions:

1. What are the factor structures of self-efficacy and attitude variables using current data?
2. What is the prevalence of mathematics self-efficacy, and attitudes towards mathematics among the study groups?
3. Are the affective variables, mathematics self-efficacy and attitudes towards mathematics, significantly correlated with mathematics achievement of first year science and engineering students?
4. Does the data indicate any gender difference in each

of the study variables?
5. How much of variance in mathematics achievement is explained by the affective variables: mathematics self-efficacy and attitudes towards mathematics?
6. Are there direct and indirect effects of gender, mathematics attitude, and mathematics self-efficacy variables on students' mathematics achievement?

THEORETICAL FRAMEWORK

This review of related literature reports the structural relationships of the cognitive and affective variables with mathematics achievement at different levels and in different contexts. These relationships were reviewed in the following sections and conceptual framework was drawn from the review to guide the current study.

Mathematics attitudes

Based on several different definitions, Aiken (1979:2) constructed attitudes as "learned predispositions to respond positively or negatively to certain objects, situations, concepts, or persons". It was further asserted that "attitudes possess cognitive (belief or knowledge) and affective (emotional or motivational) and performance (behavioral or action tendencies) dimensions" (ibid). Accordingly, mathematics attitude in this study refers to students' negative or positive predispositions to mathematics courses, mathematical tasks, and mathematics related careers. A matter of scientific interest is the nature of students' attitudes towards mathematics and the relationship between attitudes and achievement in mathematics, especially as it relates to the achievement gap in mathematics between males and females, and the lack of interest by females in science, technology, engineering, and mathematics majors (Haycock and Steen, 2002; Lutzer and Maxwell, 2000; Hacker, 2003).

It is likely to believe that one's anxiety in mathematics could be affected by their attitude towards mathematics. If one has a really poor attitude in mathematics, he/she would probably experience high anxiety in the subject. Thus, attitudes may play an important role in mathematical performance. Generally, females tend to have more negative attitudes towards mathematics than males (Hacker, 2003). Attitudes towards mathematics in adults can be traced back to childhood and tend to be more positive in younger age groups than in older age groups (Aiken, 1970). It is generally true that people who have positive attitudes towards mathematics are liable not to avoid the subject and cannot be easily frustrated when doing mathematics. In contrast, people with negative attitudes towards mathematics are more prone to be less motivated and never enjoy doing mathematics more than people with highly positive attitudes. Thus it is natural to believe that attitude influences mathematical performance (ibid). He further showed that attitude only has an effect on performance at the extremities: that is either extremely negative attitudes or extremely positive attitudes. The study also showed that attitude is a predictor of mathematical performance among females more often than males (ibid). This goes along with the findings of Eccles and Jacobs (1986:375) that social and attitudinal factors appear to have a much stronger direct effect on mathematical performance and belief in one's ability than aptitude, especially among girls.

Regarding development of instruments for measuring mathematics attitudes, the initial attempt of Dutton and Blum (1968) resulted in a measure of feelings towards arithmetic. Later Aiken (1974) constructed scales designed to measure enjoyment of mathematics and the value of mathematics. Multidimensional attitude scales were first developed by Michaels and Forsyth (1977) and by Sandman (1980). Fennema-Sherman Mathematics Attitudes Scales, which has clearly been the most popular instrument in research about attitudes toward mathematics (Fennema and Sherman, 1976), has 108 items, and served nearly for forty years now. It claims to have nine subscales, but subsequent research has questioned the validity, reliability (Suinn and Edwards, 1982), and integrity of its scores (O'Neal et al., 1988). On the other hand, Mulhern and Rae (1998) identified only six factors, but they suggested that the scales might not gauge what they were intended to measure.

The relationship of affective behavior involved in course selection, performance, achievement, and cognitive processes must be studied based solidly on a valid, reliable measure of attitudes. Thus, it is important that any research of attitudes towards mathematics use an instrument that has good technical characteristics if research findings are to be acceptable. Attitude scales must withstand factor analysis, tap important dimensions of attitudes, and require a minimum amount of time for administration. Tapia and Marsh (2004b) responded to this need for a shorter instrument with a straightforward factor structure when they developed a 40-item Attitudes towards Mathematics Inventory (ATMI). The factor structure of the ATMI covered the domain of attitudes toward mathematics, providing evidence of content validity. It resulted in four-factor solution: confidence, value, enjoyment, and motivation.

Mathematics self-efficacy

The difficult task of quantifying and monitoring key affective factors such as self-concepts, self-confidence, and self-efficacy has made research in assessing their role in mathematics learning difficult. Researchers in the field analyzed and revealed two primary areas of research interest: mathematics self-concepts and intrinsic motivations to do mathematics on one hand and willingness to study mathematics and approaches to learning on the other (Cretchley, 2008; Carmichael and Taylor, 2005; Bandura, 2005; Marsh and Hattie, 1996). The fundamental factors investigated in these two primary areas are self-concept factors and motivational factors. While self-concept factors involved mathematics talent, confidence, self-efficacy, and anxiety, the motivational factors involved interest, enjoyment, intellectual stimulation, and reward for effort, valuing mathematics, and diligence (ibid).

Some of these investigations, for example, Carmichael and Taylor (2005) revealed that there are variations in levels of specificity in use of the scale labels like confidence, motivation, and engagement. Bandura (2005) and Marsh and Hattie (1996) support using the term *self-concepts* as the full range of self-beliefs about abilities and potentials to do and learn mathematics, from broad and innate to very specific; s*elf-confidence* as self-beliefs about abilities to do and learn mathematics in some context; and *self-efficacy* as self-beliefs about the abilities to perform specific tasks. Clearly self-concept is the most general of the terms whereas self-efficacy is the most task-specific in agreement with Bandura's (1997) argument that its measurement be closely task-specific. Self-confidence, which is usually termed just confidence, conceptually lies in between the two along the line of general to specific.

Self-efficacy research in academic setting has had special focus on the relationships among efficacy beliefs, related psychological constructs and academic motivation and achievement (Schunk, 1991; Pajares and Miller, 1995) on one hand and the relationships between efficacy beliefs and college majors and career choices on the other (Betz and Hackett, 1983; Lent et al., 1989; Multon et al., 1991). Perceived self-efficacy is the level of competence one expects to display in a given situation in order to perform a given task. Self-efficacy beliefs intervene how much effort an individual puts forth, how long he or she will persist in the face of challenges, how tough he or she is in dealing with disappointments, and how much stress or depression he or she experiences in coping with challenging situations to perform the task (Bandura, 1997). Partly, such self-perceptions can be better predictors of working behavior than actual ability because these self-beliefs are influential in shaping what individuals do with the capability and understanding they have. The mediating role these self-beliefs play also helps explain why people's accomplishment may vary when they possess similar understanding and skills (Pajares and Miller, 1995).

Mathematics self-efficacy has been assessed in terms of individuals' judgments of their capabilities to solve specific mathematics problems, perform mathematics related tasks and succeed in mathematics-related courses (Betz and Hackett, 1983; Randhawa et al., 1993). This assessment of mathematics self-efficacy has given more specificity and direction to earlier global assessment of mathematics self-efficacy through confidence in learning mathematics and predicting mathematics-related behavior and performance. Mathematics self-efficacy is the focus of this study and referred to in this study as the level of competence one expects to display in a given situation in order to do mathematics, learn mathematics, perform mathematical task or pursue mathematics related careers.

Phan and Walker (2000a, 2000b) investigated the predicting and mediational role of mathematics self-efficacy using path analysis and findings revealed that students' self-efficacy beliefs about their mathematics made an independent contribution to the prediction of their mathematics problem-solving performance when other motivational variables were controlled. In addition, the information sources performance experiences, verbal persuasion, and physiological states were predictive of mathematics problem-solving performance. Mathematics self-efficacy mediated further the effects from multiple sources of self-efficacy information onto mathematics-problem performance. Regarding prior mathematics experiences, researchers exploring the predicting and mediational role of mathematics self-efficacy have reported similar findings (Pajares and Kranzler, 1995; Pajares and Miller, 1994).

Another study reported descriptive measurement reliability and validity data of high school students on scores from the Mathematics Self-Efficacy Scale-Revised (MSES-R) developed by Betz and Hackett (1986) in two contexts—class and test (Nielsen and Moore, 2003). Summated scores on the MSES-R correlated $r = .74$, and together these items yielded one component that explained 49% of the variance. MSES scores demonstrated internal reliability for both class and test (Cronbach alphas = .86 and .90) and showed statistically significant correlations with past mathematics grades.

Conceptual framework for the study

The study investigated co-relational and predictive relationships between the affective variables mathematics self-efficacy and attitudes towards mathematics with mathematics achievement of freshman students. In order to define the construct mathematics achievement, the researcher used the concept of student competence in common freshman mathematics consisting of introductory applied mathematics topics primarily calculus I and calculus II. What makes it common is that it is offered to the different science and engineering students with the same syllabus and credit hours and various teachers taught and scored tests using common standards.

The affective variable attitude towards mathematics is considered to be students' learned predispositions to respond positively or negatively to mathematical courses, tasks, and testing situations. Realizing that it possesses

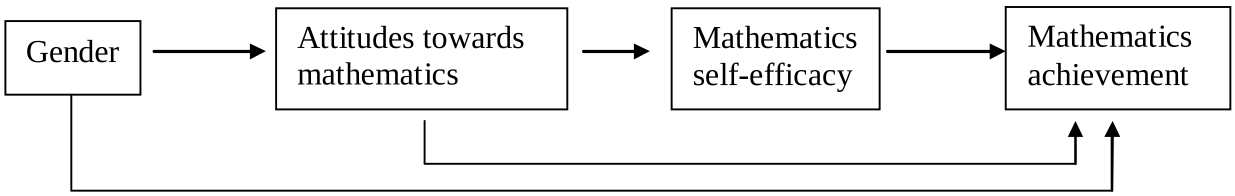

Figure 1. Conceptual framework of the study.

cognitive, affective/motivational and performance dimensions (Aiken, 1979), the researcher is interested in understanding the nature of the relationship between students' attitudes and achievement in mathematics, especially as it relates to the achievement gap in mathematics between males and females, and the lack of interest by females in science, technology, engineering, and mathematics majors. The intent was to capture students' attitudes towards mathematics activities such as problem solving exercises, group projects, end-of-unit assignments, midterm and final examinations. The Attitudes towards Mathematics Inventory (ATMI: Tapia and Marsh, 2004b) was adopted to measure the students' attitudes towards these activities.

Taking students' mathematics self-efficacy to be their belief in their capability to successfully complete an identified range of freshman mathematics activities (problem solving exercises, group projects, end-of-unit assignments, and midterm and final examinations all of which were scored), the researcher adopted MSES-R developed by Betz and Hackett (1986) to tap their beliefs in their competence in these activities. This instrument has specifically been applied in the college setting. The underpinning assumption was that the motivational variables attitude and self-efficacy play a mediatory role between gender and mathematics achievement, especially mathematics self-efficacy between mathematics attitude and mathematics achievement. This causal path has been supported by the structural model developed by Randhawa et al. (1993). Considering the variables of the study together, the following causal path was superimposed as the overarching scheme for the conceptual framework to guide the study (Figure 1).

METHODOLOGY

Subjects

The target population of the study is the freshman natural science and technology faculty students of Hawassa University enrolled in the year 2013 for three year in science and five year in engineering BSc degree programs. It was estimated over 1250 with approximate 30% females.

Samples

The study population was estimated to be over 1250 students, of which 274 (214 male, 60 female) were randomly included in the sample of the study using stratified random sampling. The stratifying variables were gender and department in each field of study, that is, science and engineering. The sample was nearly 22% of the population. The sampling process observed the principle of proportionality to population size. Comparable sample sizes (53, 54, 54, 52 and 61 participants) were taken from each of the five departments of the study, namely Physics, Mathematics, Computer Science, Electrical Engineering, and Civil and Urban Engineering, respectively (Table 1).

Instruments

The study looked into co-relational and predictive relationships between mathematics self-efficacy and attitudes towards mathematics with mathematics achievement of freshman students. To measure the mathematics self-efficacy of students, the researcher adopted Mathematics self-efficacy Scale-Revised (MSES-R) developed by Betz and Hackett (1986), which was intentionally devised to assess mathematics self-efficacy of college students. The instrument has 25 items and three subscales representing three domains of mathematics-related behavior. The Attitudes towards Mathematics Inventory (ATMI: Tapia and Marsh, 2004b) was used to measure the students' attitudes toward mathematics. Exploratory factor analysis of the ATMI (Tapia and Marsh, 2004b) with 40 items resulted in four factors identified as Self-confidence, Value of mathematics, Enjoyment of mathematics, and Motivation. The Self-confidence factor consists of 15 items. The Value factor and the Enjoyment factor each consists of 10 items. The motivation factor consists of 5 items. These 5 items were used to measure motivation in this study; the other 35 items of ATMI were used to measure non-motivational dimension of attitude towards mathematics of students in the study. Each of these instruments presented to students with 5-point Likert type scale (statement) with 1-5 for the students to indicate whether they strongly agree = 5, agree = 4, undecided = 3, disagree = 2, or strongly disagree = 1.

The two instruments were pilot tested before final administration using responses from 45 students, 15 from each department. There was no need for translating the instruments into local language because English is the language of instruction in Hawassa University. However, two psychometrics professors were asked to independently review the items in the instruments for clarity and checking of cultural bias, if any. They ensured the use of the instruments with minor changes of words or phrases to address possible ambiguity. Technical assistants took part in coordinating the process of final data collection after they were given strict training and orientation about the data collection. These assistants from each faculty distributed the instruments in each faculty and collect the filled ones. According to the pilot test results, ATMI summated score had minimum item-total correlation r = .70 and that of MSES-R had r = .65 showing that the instruments demonstrated fair reliability with this sample size.

The freshman science and technology students take two Applied

Table 1. Samples by department and gender.

Department	Gender		Total
	Male	Female	
Physics	43	10	53
Mathematics	41	13	54
Computer Science	42	12	54
Electrical Engineering	43	9	52
Civil and Urban Engineering	45	16	61
Total	214	60	274

Mathematics courses in their first year. These are Calculus I and Calculus II the contents of which cover all major calculus topics. The first course is introductory calculus, significant portion of which is a revision of what the students actually took in their preparatory years in school. The second course introduces more or less advanced topics with a more rigorous level of treatment. In both semesters many students exhibit stress and anxiety in performing mathematics problems and mathematics-related tasks. In order to determine the predictive roles of the various affective variables of the study, the researcher used the final scores in these courses from the student records office. The final scores for mathematics achievement depended on marks each instructor assigned on successive assessment of students' work concerning assignments, mid-semester and final exams of each semester. The average of the two semester results were used as final scores.

Methods of analysis

Both descriptive and inferential statistical methods were used to analyze the data. Factor analyses were conducted to identify the dimensions of predictor variables. Descriptive statistics and independent t-test were used to obtain means and SD to determine the levels of the study variables and compare gender differences. Correlations of the different study variables were computed by way of preparation for determining effects of affective variables on student achievement. Finally, path analyses were employed to trace the amount of direct and indirect effects of attitudes and self-efficacy on mathematics achievement.

RESULTS AND DISCUSSION

Here, the attempts were made to answer the basic research questions. More specifically, the questions regarding the construct validity of the instruments adopted for this research, the level of perceived mathematics self-efficacy and attitudes of students, gender difference in the level of the study variables, and direct and indirect effects of the motivational variables on mathematics achievement were attempted. The data obtained from mathematics self-efficacy and attitude scales as well as student performance evaluation were statistically analyzed and presented in Table 2.

The response rate for each sample group is at least 70%. The overall response rate is 89.42%, which can be considered as fairly high. Twenty nine cases were discarded because they were either incomplete or inappropriately filled. Most of these non-response cases were from the science departments. On the other hand, Computer science and Electrical Engineering departments responded 100%.

Factor structures of the affective variables

One of the study objectives is to analyze the factor structure of the scale of each of the affective variables, mathematics self-efficacy and attitude based on data. Students were actually asked to rate a 5-point Likert type scale in each of the two affective variables. For each instrument, the items coined in the negative sense of the main scale were recorded positively so that they match up with the rest of the items in summating of scores into total score. The item-responses were used for factor analysis to determine the subscales of each of the variables. The results of this data reduction process are presented in Table 3.

The criteria for validity of use of factor scores was checked before using the factors identified in the factor analyses. Accordingly, the factorability of the 40 ATMI items and 25 MSES-R items was examined separately. In each case, several well-recognized criteria for the factorability of correlation were used. These were the item-total correlation coefficients for each subscale, the Kaiser-Meyer-Olkin measure of sampling adequacy, and the Bartlett's test of sphericity, the anti- image correlation matrix and the communalities. The factor analyses used principal components extraction applying varimax rotation method to identify the subscales. The results of each analysis are reported in Table 3.

First, all the items in each scale correlated at least .34 with at least one other item suggesting reasonable factorability. Secondly, the minimum KMO measure of sampling adequacy was .85, above the recommended value of .6, and the Bartlett's test of sphericity was significant for each scale (Table 3). The diagonals of the anti-image correlation matrix for each scale contained values over .70, supporting the inclusion of each item in the factor analysis. The communalities in each analysis resulted in .3 or above showing that each item in each factor analysis shared some common variance with another item. These results led the researcher to accept the factors as valid measures of the subscales.

Table 2. Response rates.

Department	Gender		Total	Response rate (%)
	Male	Female		
Physics	35	4	39	73.59
Mathematics	33	10	43	79.63
Computer Science	47	7	54	100
Electrical Engineering	45	7	52	100
Civil & Urban Engineering	41	16	57	93.44
Total	201	44	245	89.42

Table 3. Means, standard deviations, reliabilities, and percentage of explained variances (N = 245).

Parameter	No. of items	Scale mean	Item mean	Item SD	Cronbach alpha	% of explained variance	Factorability statistics
MA		70.76		13.35			
ATMI	40*	135.80	3.40	12.09	.85	60.29	KMO = .854 Chi-sq=346.5, df=780, p<.01, Anti-image diag.>.70
CM	15	56.24	3.75	. 68	. 91	17.73	
VM	10	46.60	4.36	.46	.82	16.58	
EM	10	38.40	3.84	.65	.81	15.84	
Mot	5	9.75	1.95	.67	.83	10.14	
MSE	25	84.08	3.36	8.80	.82	43.84	KMO=.967 Chi-sq=3360, df=780, p<.05, Anti-image diag>.72
MCSE	13	45.55	3.50	.56	.84	18.17	
EMSE	6	24.77	4.13	.68	.86	15.76	
RMSE	6	13.76	2.29	.61	.79	9.91	

*One item dropped because its loading is less than .3; MA=Mathematics achievement; ATMI= Attitude towards mathematics inventory, MSE= Mathematics self-efficacy scale (revised), CM=Confidence in mathematics, VM=valuing mathematics, Mot=Motivation in mathematics, EM=Enjoy doing mathematics, MCSE=Mathematics capability self-efficacy, EMSE=Engagement in mathematics self-efficacy, CRMSE=Career-related mathematics self-efficacy.

Mathematics attitudes subscales

Four factors or subscales of ATMI scale were determined as expected based on data from 245 students using 40 items. These are: Confidence in doing mathematics (15 items), valuing mathematics (10 items), enjoy doing mathematics (10 items) and motivation (5 items). The items included, for example, “I have a lot of self-confidence when it comes to mathematics” (Confidence item), “Mathematics is important in everyday life” (Value item), “Mathematics is a very interesting subject to me” (Motivation item), and “I have usually enjoyed studying mathematics in school” (Enjoyment item). Reliability estimate for ATMI was .85, whereas the individual subscales had reliability estimates varying between .81 and .91.

Mathematics self-efficacy subscales

The MSE scale yielded three factors based on data using 25 items. These are: Mathematics problem solving capability self-efficacy (13 items), Engagement in mathematical tasks (6 items), and Career-related mathematics self-efficacy (6 items). The items included, for example, “Generally, I am confident in attempting mathematics” (Mathematics problem-solving capability item), “I can engage myself with studying mathematics when preparing for its test” (Engagement item), and “I can use mathematics skills for earning living” (Career-related item). Reliability estimate for MSES-R was .82, whereas the individual subscales had reliability estimates varying between .79 and .86. The reliability estimates increased as compared to pilot result due to increased sample size of the main study.

The study sought to understand the factor structures of attitude and self-efficacy variables. As Table 3 depicts, the subscales of each scale have been separated with a good factorability indicators. That is, sampling was adequate; inclusion of each item in each factor analysis was valid; sphericity is acceptable; and commonalities showed that each item in each analysis shared significant common variance. Moreover, the data confirm earlier studies including the results of developers as well as users of the scales (Betz and Hackett, 1986; Tapia and Marsh, 2004b; Pajares and Miller, 1995). There were some results that show order of potency among the attitude subscales, the most dominant subscale being *confidence in doing mathematics,* whereas the least visible factor is *enjoying doing mathematics.* It was also observed in the analysis that the items in this factor loaded on the *motivation* factor when three-factor solution was tried.

The particular interests in this study are mathematics self-efficacy and attitudes because social science literature on widening academic participation suggests that a positive disposition towards a subject is crucial to continuing to study a subject or use it (Bandura and Cervone, 1983; Bandura and Locke, 2003). The predominance of these affective variables needs to be assessed among the study groups so that the university becomes informed as to how to guide the incoming students to enhance their attitude and efficacy to mathematics and mathematical tasks.

Summary of the prevalence of the affective variables

The preceding sections showed the factor structures of each of the attitude and self-efficacy variables using the data. The second objective of the study is to show the prevalence of these variables among the freshman science and technology students. Table 3 shows the summated score means, item means, scale standard deviations, reliabilities, and percentage of explained variances of each subscale under each of the two scales. It presents the typical prevalence of the affective variables and mathematics performance for the overall data, which might vary across gender and departments. For the ease of interpretation, item mean value 1 through 1.50 is considered very low; 1.50 through 2.50 is low; 2.50 through 3.50 is moderate; 3.50 through 4.50 is high; and 4.50 through 5 is very high prevalence in each scale and subscale.

Generally speaking, the attitudes towards mathematics and mathematics self-efficacy are moderate (ATMI mean = 3.40; MSE mean = 3.36). When we look into the subscales of the attitude scale, students fall short in their motivation in mathematics (Mot mean = 1.95). Both confidence in mathematics and enjoying doing mathematics is marginally high probably due to their low motivation to become engaged more in working mathematics. On the other hand, students have high scores in valuing mathematics (VM mean = 4.36). This means they have high perceptions on importance, use, and applications of mathematics outside the class in everyday life in science and engineering. This might be related to the high capability self-efficacy and engagement self-efficacy (MCSE mean = 3.50, EMSE mean = 4.13). Compatible with this, the attitude dimension of valuing mathematics, that is, use and application of mathematics, seems to be high, as are students' confidence in mathematics.

Gender role in influencing motivational variables and mathematics performance

Does the data indicate any gender difference in each of the study variables? Different researchers obtained results that revealed that mathematics self-efficacy, gender and anxiety have significant correlations with student's mathematics achievement (Ayotola and Adedeji, 2009; Hyde et al., 1990). The general consensus in the related research is that males do outperform females in mathematics achievement, but this difference does not really emerge until adolescence (Pajares and Miller, 1994). The difference is also more prevalent when it comes to problem solving. Interestingly, females tend to have higher grades on teacher reports than males do (Hyde, et.al, 1990:300). These findings were consistent with those of other investigations (Hacker, 2003). It is against this background that this study looked at gender difference in attitude towards mathematics, mathematics self-efficacy and mathematics achievement.

This study revealed that there is significant gender difference in mathematics achievement, ($t = 2.84$, $p < .05$), and only in two of MSE subscales, *mathematics capability self-efficacy* ($t = 2.67$, $p < .05$) and e*ngagement in mathematics self-efficacy* ($t = 2.08$, $p < .05$) (Table 4). One dares to ask, what could be the driving force behind males outscoring females on freshman mathematics achievement tests? Eccles and Jacobs (1986) argue that standardized performance tests are not true measures of innate mathematical ability due to many factors that can affect performance such as test anxiety, risk-taking preferences, cognitive style, and confidence in one's abilities (p. 369). According to Eccles and Jacobs (1986), "sex differences in mathematical achievement and attitudes are largely because of sex differences in math-anxiety, the gender-stereotyped beliefs of parents, especially mothers; and the value students attach to mathematics" (p. 370). The insignificant results in the other motivational variables might be indicating that more focus should be on enhancing girls' mathematics self-efficacy through encouraging them to do exercise in mathematics and to engage themselves in problem solving tasks.

Summary of the correlations of the affective variables and mathematics performance

One of the objectives of this study is to look into the degree of association mathematics achievement has with the affective variables mathematics self-efficacy and attitudes towards mathematics using data from first year science and engineering students. As can be seen in Table 5, mathematics achievement is significantly correlated with four subscales: the attitude subscale

Table 4. The t-test summary of gender difference.

Parameter	Male		Female		Df	T	Sig.
	M	SD	M	SD			
MA	71.88	12.58	65.66	15.58	243	2.84*	.005
CM	3.79	.65	3.55	.77	223	1.98	.049
VM	4.38	.45	4.29	.50	235	1.19	.234
EM	3.83	.66	3.90	.58	240	-.63	.528
Mot	1.94	.67	1.98	.65	227	-.40	.686
MCSE	3.55	.55	3.29	.58	228	2.67*	.008
EMSE	4.17	.65	3.93	.80	238	2.08*	.038
CRSE	2.67	.60	2.41	.67	239	-1.40	.239

* p < .05, **p < .01; Variable abbreviations are as in Table 3.

Table 5. Correlations of the affective variables and mathematics performance.

		MA	ATMI				MSE			Gen
		1	2	3	4	5	6	7	8	9
1	MA	1	.42**	-	-	-	.45**	.37**	.27**	.18*
2	CM		1	.60**	.54**	.46**	.81**	.39**	.47**	.13*
3	VM			1	.52**	.41**	.53**	.39**	.40**	-
4	EM				1	.37**	.29**	.29**	57**	-
5	Mot					1	.22*	.30**	.29**	-
6	MCSE						1	.43**	.46**	-.17*
7	EMSE							1	.21*	-.13*
8	CRSE								1	-
9	Gen									1

Note: Only significant correlations are displayed, * p<.05, **p<.01; Variable abbreviations are as in Table 3.

confidence in mathematics (r = .42, p < .01), self-efficacy subscales, *mathematics capability self-efficacy* (r = .45, p < .01), e*ngagement in dong mathematics self-efficacy* (r=.37, p < .01), and *career-related self-efficacy* (r = .27, p < .05).

All intra-correlations and inter-correlations among subscales of each scale are positive and significant (p < .05) as expected from the theoretical relationships among the constructs mathematics attitude and self-efficacy. The significant positive correlations of CM, MCSE, EMSE and CRSE with mathematics achievement, suggest that they may contribute to the predictive model for their effects on mathematics achievement.

Predictive roles of affective variables in mathematics achievement

This study aimed at understanding how much of the variance in mathematics achievement was explained by the affective variables: attitudes towards mathematics and mathematics self-efficacy. A path analysis was employed to examine the direct and indirect effects of the variables including gender. Path analysis is a multiple regression procedure that looks into causal pathways between variables showing the direct and indirect effects of a variable on a given dependent variable (Pedhazur, 1997). It is a straightforward extension of multiple regression aiming at providing estimates of the magnitude and significance of hypothesized causal connections between sets of variables. This is best explained in a path diagram in Figure 2.

The advantage of path analysis is that you can see which variables exert effects on others, whether these are direct, indirect or detect fake paths. A direct effect is one between two variables with no intervening variable; indirect effects are those that are mediated through some intermediary variable. In Figure 2, for example, gender is assumed to exert a direct effect on MA. It also exerts an indirect effect on MA through CM and MCSE. Here we note that gender would be considered *exogenous* (there is no arrow pointing towards it) and MA and CM *endogenous* (both have arrows pointing towards them).

Effects of mathematics self-efficacy variables on mathematics achievement are hypothesized at the first rate though the researcher anticipated the role of attitude variables as well. Both attitudes and self-efficacy variables were known to mediate the effect of gender on

Table 6. Direct and indirect effects of gender and ATMI variables.

Effect	R^2	Direct	Indirect	Total	Error
On Math Achievement					
Of Gender		-.183*	-.018	-.165*	
Of CM		.081	.142*	.223*	.925
Of VM	.075	-	.039	.039	
Of MCSE		.188*	-	.188*	
Of EMSE		.201*	-	.201*	
On MCSE					
Of CM	.656	.753**	-	.753**	.344
Of VM		.09		.09	
On EMSE					
Of CM	.206	.218*	-	.218*	.794
Of VM		.194*	-	.194*	
On CRSE					
Of CM	.376	.254*	-	.254*	.624
Of Mot		.467**	-	.467**	
On CM					.983
Of Gen	.017	-.131	-	-.13	

Note: Variable abbreviations are as under Table 3; **p < .01, *p < .05. Gen = 1 for male, 2 for female.

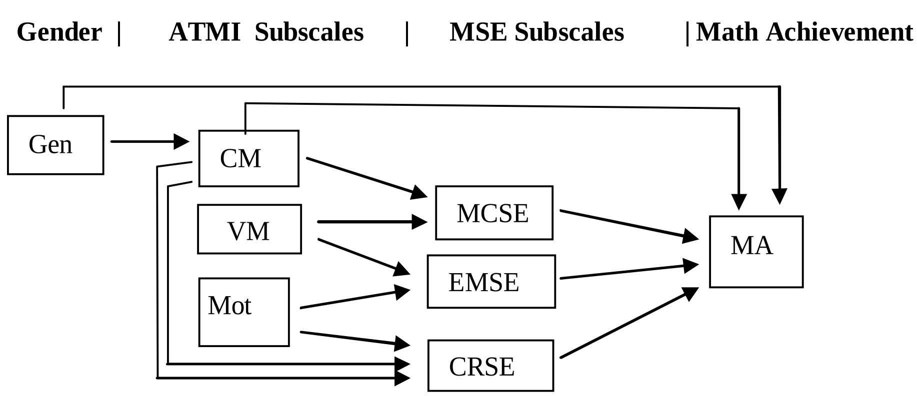

Figure 2. Initial path model for the effects of gender and motivational variables on mathematics achievement. Note: Variable abbreviations are as under Table 3.

mathematics performance (Pajares and Miller, 1994). The effect of attitudes towards mathematics is also mediated by students' mathematics self-efficacy beliefs (Randhawa et al., 1993). Based on such empirical evidences and the significant correlations observed in the data (Table 5), the following *input* path diagram (Figure 2) was put forward to see the effects. The input path diagram is one that is drawn beforehand to help plan the analysis and represents the causal connections that are proposed by our hypothesis. The *output* path diagram (Figure 3) represents the results of path analysis, and shows what was actually found based on data. The significant correlations among the study variables (Table 5) give us some clues as to which variables could lead to mathematics achievement. The appropriate entry type in this regression analysis in order to identify significant variance contributors is standard *enter* selection (Foster et al., 2006). One of the indicators of this is strong correlation of independent variable with the dependent variable. Accordingly, the researcher identified the initial or input model showing the hypothesized paths leading to endogenous variables (Figure 2). Then five separate regressions were run to explain the five endogenous variables in the input model. Gender values assume 1 for males and 2 for females for the sake of these regressions. The first has mathematics achievement as the dependent variable. With βs representing the computed regression coefficients, the regression

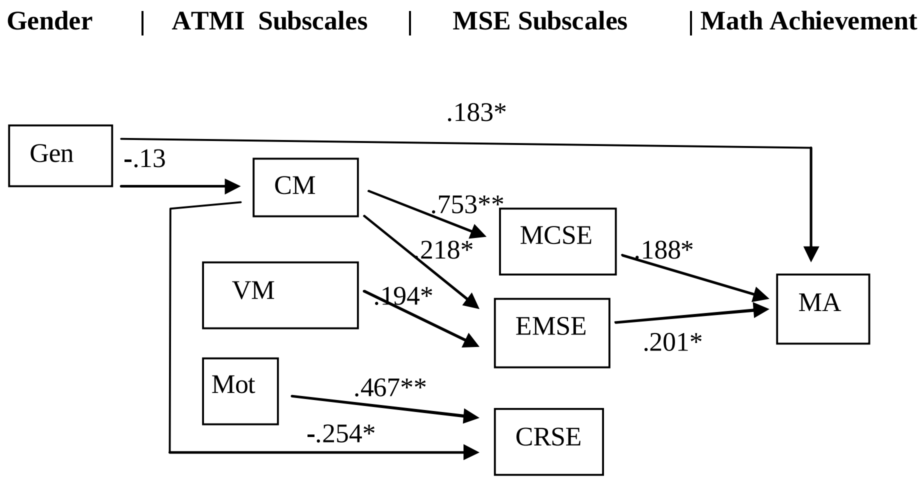

Figure 3. Output path model for the effects of gender and motivational variables on mathematics achievement. Note: Variable abbreviations are as under Table 3.

equation represents the pathway:

$$MA = \beta_1 Gen + \beta_2 CM + \beta_3 MCSE + \beta_4 EMSE + \beta_5 CRSE \quad (1)$$

The regression for MA yielded the following beta values: β_1 =.18*, β_2 =.07, β_3 =.18*, β_4 =.20*, β_5 =.03, only three of which were significant paths. The non-significant paths are removed from the output model. The R-square computed by SPSS was .752 showing that 75.2 % of the variation in mathematics achievement is accounted for by this model. The paths leading to MA through attitude variable CM seems to be insignificant because the direct effect of gender on this variable was insignificant (See β_{13}= -.13 below). On the other hand, it is hypothesized that the MSE variables behave as intermediary variables between ATMI variables and MA, so we look into the paths leading from ATMI variables to MSE variables.

Thus each of the 2nd through 5th regression analyses had the MSE variables MCSE, EMSE, and CRSE, and the ATMI variable CM as the dependent variable, so the regression equations were:

$$MCSE = \beta_6 CM + \beta_7 VM \quad (2)$$
$$EMSE = \beta_8 Gen + \beta_9 CM + \beta_{10} VM + \beta_{11} Mot \quad (3)$$
$$CRSE = \beta_{12} CM + \beta_{13} Mot \quad (4)$$
$$CM = \beta_{14} Gen \quad (5)$$

The resulting beta values were: β_6 =.75*, and β_7 =.09 from 2nd regression; β_8=-.13, β_9 =.21*, β_{10}=.19*, and β_{11} =.10 from the 3rd regression; β_{12}=-.25*, and β_{13} =.46* from 4th regression; and β_{14}= -.13 from the last regression equation. Inputting the significant beta values into the path diagram Figure 2 gives Figure 3. The R-square values for the paths were: .075, .656*, .206*, .376*, and .013, respectively. Each indicates the total variance in the respective endogenous variable explained by the path. The corresponding error in estimation of each path coefficient becomes $1-R^2$. It is clear that the error is large for mathematics achievement and self-confidence indicating that the portion of unexplained variance in each is large. This means, in other words, there are other predictors not included in the models. This is further depicted by the small beta weights obtained by these models. Yet the direct effects of gender and the self-efficacy variables on mathematics achievement were significant at 5% level of significance, whereas only one of the attitude variables, self-confidence in mathematics, showed significant indirect effect on mathematics achievement (Table 6).

Thus it can be concluded that the self-efficacy variables contribute direct effects on mathematics achievement while the attitude variables may have indirect effects through the self-efficacy variables and possibly through other predictors not included in the model. These findings on the predictive and mediational role of self-efficacy are supported by different studies (Multon et al., 1991; Ma, 1997; Ma and Kishor, 1997; Ma and Xu, 2004). In addition, researchers who have looked into the relationship between mathematics self-efficacy and various mathematics outcomes reported significant correlations and strong direct effects (Hackett and Bent, 1989; Pajares and Miller, 1994, 1995a, b).

Pajares and Miller (1994) used path analysis to investigate mathematics problem solving from a social cognitive perspective and found that self-efficacy with regard to solving mathematics problems was more predictive of that performance than were prior determinants such as gender or mathematics background or variables such as mathematics anxiety, mathematics self-concept, and the perceived usefulness of mathematics. They also showed that boys and girls differed in performance, but the difference was mediated by the students' self-efficacy perceptions. That is, the poorer performance of girls was largely due to lower judgments of their capability. Mathematics self-efficacy could be the best predictor of mathematics achievement followed by gender and anxiety. The need for educational stakeholders and curriculum planners to design programs that will enhance mathematics self-efficacy of students is obvious. Research has indicated that self-efficacy could be increased by using the right instructional strategies (Schunk, 1991), such as helping students to set learning goals (Bandura, 1997; Schunk, 1991), giving timely and explicit feedback (Bandura, 1997), encouraging students to study harder (Siegle and McCoach, 2007), and using high achieving students as models (Bandura, 1986; Schunk, 1991; Siegle and McCoach, 2007).

Summary of the findings

The data exhibited the factor structures of the variables of the study to quite satisfactory level. It also depicted gender difference in mathematics achievement, and in two self-efficacy subscales: Mathematics capability and engagement in mathematics self-efficacy. While all the intra- and inter-correlations of the affective variables are positive and significant, only confidence dimension of attitude scale and all self-efficacy subscales significantly correlated with mathematics achievement. Moreover, the direct effects of gender and of the self-efficacy subscales on mathematics achievement were significant as expected based on literature. On the other hand, direct effects of gender and all attitude variables on mathematics were not significant, while they show some significant indirect effects on mathematics achievement through some self-efficacy variables.

CONCLUSIONS

The following conclusions were drawn based on data:

1. For attitudes towards mathematics, four subscales emerged as:

a) Self-confidence – measuring students' confidence and self-concept of their performance in mathematics.
b) Value - measuring students' beliefs on the usefulness, relevance and worth of mathematics in their life now and in the future.
c) Enjoyment - measuring the degree to which students enjoy working mathematics problems and following mathematics classes.
d) Motivation - measure interest in mathematics and desire to pursue studies in mathematics.

2. The factor structures of self-efficacy and attitude variables were established from data, which is more or less in agreement with the literature. For mathematics self-efficacy variable the usual three-factor solution was obtained. The three subscales were:

a) Mathematics capability self-efficacy - measuring problem solving efficacy,
b) Engagement in doing mathematics self-efficacy - measuring the students' effectiveness to engage themselves in doing mathematics,
c) Course related self-efficacy - measuring the students' effectiveness to courses related to mathematics and mathematical tasks or fields.

3. The attitudes towards mathematics and mathematics self-efficacy are at moderate level for the study groups. More specifically, students' motivation towards mathematics is just below average. Both confidence in mathematics and enjoying doing mathematics is marginally high, probably due to their low motivation to become engaged in working mathematics. On the other hand, students have high scores in valuing mathematics, which might be due to their high perceptions on importance, use, and applications of mathematics outside the class in everyday life in science and engineering.
4. The high value attitude might have contributed to the high problem solving self-efficacy and engagement self-efficacy observed among the study groups. The motivational variables: mathematics self-efficacy and attitudes towards mathematics significantly correlated with mathematics achievement of first year science and engineering students.
5. There is significant gender difference in mathematics achievement and only in two of self-efficacy subscales, mathematics capability self-efficacy and engagement in mathematics self-efficacy.
6. The amount of variance in mathematics achievement explained by the motivational variables, mathematics self-efficacy and attitudes towards mathematics, is low. There may be other important predictors not included in the models. This is further depicted by the small, but significant, betas obtained by the models. However, the direct effects of gender and the self-efficacy variables on mathematics achievement were significant at 5% level of significance, whereas only one of the attitude variables, self-confidence in mathematics, showed significant indirect effect on mathematics achievement. It seems that the self-efficacy variables contribute direct effects on mathematics achievement while the attitude variables have indirect effects through the self-efficacy variables and possibly other predictors not included in the model.

RECOMMENDATIONS

The study forewords the following recommendations:

1. The validation of measures of attitudes and self-efficacy has resulted in seemingly robust in terms of fit

statistics and overall measures of reliability. However, care should be taken to consider how they can be used with different subgroups of the population in a given study. So, factor structure of behavioral constructs has to be examined further by employing multidimensional models.

2. Students' high valuing of mathematics has to be used as an opportunity to enhance their motivation and efficacy. Efforts are needed for promoting mathematics attitudes and mathematics self-efficacy for freshman students because attitudes towards mathematics boosts mathematics self-efficacy and mathematics self-efficacy has strong predictive role positively affecting mathematics achievement. Mathematics teachers and teachers in the fields of science and engineering have a crucial role to play in using the right instructional strategies, such as helping students to set learning goals, giving timely and explicit feedback, encouraging students to study harder, and using high achieving students as models.

3. The observed gender difference in mathematics achievement and self-efficacy variables such problem solving and being engaged in mathematics works, with lower performance among girls is alerting educators as well as department leadership to plan for supporting female students more than ever. Special tutorial sessions for girls, setting of goals for girls and mentoring by guidance and counseling, female teachers and high achieving students in the departments as models, arranging special study rooms with necessary learning materials and mentors may be strategic approaches to tackle the problem.

4. The teaching force in the area of mathematics and engineering may currently be less experienced than what the need demands. The university should persist in improving their pedagogical capabilities through continued training and enhancing working conditions in terms of the supply of learning materials such as books, and computers.

REFERENCES

Aiken, L. R. (**1970**). Attitude towards mathematics. Review of Educational Research, 40(4):551-596.

Aiken, L. R. (**1974**). Two scales of attitude toward mathematics. Journal for Research in Mathematics Education, 5:67-71.

Aiken, L. R. (**1979**). Attitudes toward mathematics and science in Iranian middle schools. School Science and Mathematics, 79:229-234.

Ayotola, A., and **Adedeji**, T. (**2009**). The relationship between gender, age, mental ability, anxiety, mathematics self-efficacy and achievement in mathematics. Cypriot Journal of Educational Sciences. 4:113-124.

Bandura, A. (**1986**). Social foundations of thought and action: A social cognitive theory.

Bandura, A. (**1997**). Self-efficacy: The exercise of control. New York: W. H. Freeman.

Bandura, A. (**2005**). Guide for constructing self-efficacy scales. In Pajares & Urban (Eds.), Self-efficacy beliefs of adolescence (adolescence & education). Information Age Publishing.

Bandura, A., and **Cervone**, D. (**1983**). Self-Evaluative and Self-Efficacy Mechanisms. John Wiley and Sons.

Bandura, A., and **Locke**, E. A. (**2003**). Negative self-efficacy and goal effects. Journal of Applied Psychology, 88(1):87–99.

Bandura, A., Barbaranelli, C., Cprara, G. V., and Pastorelli, C. (**2001**). Self-efficacy beliefs as shapers of children's aspiration and career trajectories. Child Development, 72(1):187-206.

Betz, N. E., and **Hackett**, G. (**1983**). The relationship of mathematics self-efficacy expectations to the selection of science-based college majors. Journal of Vocational Behavior, 23:329-345.

Betz, N. E., and **Hackett**, G. (**1986**). Applications of self-efficacy theory to understanding career choice behavior. Journal of Social and Clinical Psychology, 4:279–289.

Carmichael, C., and **Taylor**, J. (**2005**). Analysis of student beliefs in a tertiary preparatory mathematics course. Proceedings of Delta'05, iJMEST, 36(7):713-720.

Cretchley, P. C. (**2008**). Advancing Research into Affective Factors in Mathematics Learning: Clarifying Key Factors, Terminology and Measurement. Proceedings of 31st Annual Conference of Mathematics Education Research Group of Australia. Eds. M. Goose, R. Brown, and K. Mark. University of Queensland.

Dutton, W. H., and **Blum**, M. P. (**1968**). The measurement of attitudes toward arithmetic with a Likert-type test. Elementary School Journal, 68:259-264.

Eccles, J. S., and **Jacobs**, J. E. (**1986**). Social forces shape math attitudes and perfomance Englewood Cliffs, NJ: Prentice Hall.

Fennema, E., and **Sherman**, J. A. (**1976**). Fennema-Sherman mathematics attitudes scales: Instruments designed to measure attitudes toward the learning of mathematics by females and males. Journal for Research in Mathematics Education, 7(5), 324-326.

Foster, E., Barkus E., and Yavorisky, C. (**2006**). Understanding and using advanced statistics. Sage Publications Ltd. London.

Gal, L. B., and **Ginsberg**, L. (**1994**). The role of beliefs and attitudes in learning statistics: Toward an assessment framework. Journal of Statistics Education, 2, 2.

Hacker, A. (**2003**). How the B.A. gap widens the chasm between men and women. The Chronicle of Higher Education. Retrieved April 1, 2004, from http: chronicle.com/prm/weekly/v49/i41/41b01001.htm.

Haycock, K., and **Steen**, L. A. (**2002**). Add it up: Mathematics education in the U.S. does not compute. Thinking K - 16, 6, 1.

Hyde, J., Fennema, E., Ryan, M., Frost, L. A., and Hopp, C. (**1990**). Gender comparisons of mathematics attitude and affect. Psychology of Women Quarterly, 14(3):299-324.

Klassen, R. M. (**2004**). A cross-cultural investigation of the efficacy beliefs of South Asian immigrant and Anglo Canadian nonimmigrant early adolescents. Journal of Educational Psychology, 96(4):731-742.

Lent, R. W., Brown, S. D., and Larkin, K. C. (**1989**). Relation of self-efficacy expectations to academic achievement and persistence. Journal of Counseling Psychology, 31(3):356-362.

Lutzer, D. J., and **Maxwell**, J. W. (**2000**). Statistical abstract of undergraduate programs in the mathematical sciences in the United States. Washington, DC: Conference Board of Mathematical Sciences.

Ma, X. (**1997**). Reciprocal relationships between attitude toward mathematics and achievement. Journal of Educational Research, 90:221-229.

Ma, X., and **Kishor**, N. (1997). Assessing the relationship between attitude towards mathematics and achievement in mathematics: A meta-anlaysis. Journal for Research in Mathematics Education, 28:26-47.

Ma, X., and **Xu**, J. (**2004**). Determining the causal ordering between attitude toward males and females. Journal for Research in Mathematics Education, 7:324-326.

Marsh, H. W., and **Hattie**, J. (**1996**). Theoretical perspectives on the structure of self-concept. In B. A. Bracken, (Ed.) Handbook of self-concept. New York, NY: Wiley.

Michaels, L. A., and **Forsyth**, R. A. (**1977**). Construction and validation of an instrument measuring certain attitudes toward mathematics. Educational and Psychological Measurement, 37(4):1043-1049.

Mulhern, F., and **Rae**, G. (**1998**). Development of a shortened form of the Fennema-Sherman Mathematics Attitudes Scales. Educational and Psychological Measurement, 58(2):295-306.

Multon, K. D., Brown, S. A., and Lent, R. W. (**1991**). Relation of self-efficacy beliefs to academic outcomes: a meta-analytic investigation. Journal of Counseling Psychology, 38:30-38.

Nielsen, I. L., and **Moore**, K. A. (**2003**). Psychometric data on the Mathematics Self-Efficacy Scale. Educational and Psychological Measurement, 63(1):128-138

O'Neal, M. R., Ernest, P. S., McLean, J. E., and Templeton, S. M. (**1988**). Factorial validity of the Fennema-Sherman attitude scales. Paper presented at the annual meeting of the Southwest Chapter of AERA.

Pajares, F., and **Kranzler**, J. (**1995**). Self-Efficacy beliefs and general mental ability in mathematical problem solving. Contemporary Educational Psychology, 20:426-443.

Pajares, F., and **Miller**, M. D. (**1994**). The role of self-efficacy and self concept beliefs in mathematical problem-solving: A path analysis. Journal of Educational Psychology, 86:193-203.

Pajares, F., and **Miller**, M. D. (**1995**). Mathematics self-efficacy and mathematics performance: The need for specificity of assessment. Journal of Educational Psychology, 42:190-198.

Pedhazur, E. J. (**1997**). Multiple Regression in Behavioral Research (3rd Ed). Fort Worth: Hartcourt Brace College Publishers.

Phan, H., and **Walker**, R. (**2000a**). The Predicting and Mediational Role of Mathematics Self-efficacy: A Path Analysis.

Phan, H., and **Walker**, R. (**2000b**). Maths Self-efficacy in Primary Schools: Evidence of a Hierarchical Structure. Paper Presented at the Inaugural International Self-Concept Conference. Self Research Centre, 5th-6th October.

Randhawa, B. S., Beamer, J. E., and Lundberg, I. (**1993**). Role of mathematics self-efficacy in the structural model of mathematics achievement. Journal of Educational Psychology, 85:41-48.

Sandman, R. S. (**1980**). The mathematics attitude inventory: Instrument and user’s annual. Journal for Research in Mathematics Education, 11(2):148-149.

Schunk, D. H. (**1991**). Self-efficacy and academic motivation. Educational Psychologist, 26:207-231.

Stevenson, H. W., Lee, S. Y., and Stigler, J. W. (**1986**). Mathematics achievement of Chinese, Japanese, and American children. Science, 231(4739):693-699.

Tapia, M., and **Marsh**, G. E. (**2004a**). Attitudes toward mathematics of pre-calculus students. Center for Teaching-Learning, Gale Group: Thompson Corporation Company.

Tapia, M., and **Marsh**, G. E. (**2004b**). An instrument to measure mathematics attitudes. Academic Exchange Quarterly, 8(2):16-21.

Tobias, S. (**1995**). Overcoming Mathematics Anxiety, Revised and Expanded. W.W. Norton & Company, New York. University of Florida Counseling Center Web Page, accessed (July 22, 2013).

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