Predictors of Student Motivation to Succeed in First-Year College Mathematics: A Quantitative Analysis[4]

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ABSTRACT: The paper investigated whether students' mathematical self-concept and demographic characteristics could be used to predict students' motivation to succeed in first-year college mathematics. A sample of 407 participants consisting of 233 male and 174 female students were surveyed with a 40-item Questionnaire that sought to measure students' mathematical self-concept and motivation. Confirmatory factor analysis supported the existence of a mathematical self-concept scale and four motivational subscales (intrinsic motivation: relevance/significance of math; perception of math; interest/enjoyment of math; & extrinsic motivation: expectation of future income). The correlations among the motivation, self-concept, and demographic variables revealed theoretically consistent interrelationships. Multiple regression analyses indicated that mathematics self-concept, demographic variables, and extrinsic motivational factor accounted for significant amounts of the variance in students' motivation to succeed in first-year college mathematics. The results are discussed in relation to current theory and their implications for teaching and learning mathematics.

RESUMÉ: on a cherché à savoir si la perception que les étudiants ont des mathématiques et si leurs caractéristiques démographiques pouvaient jouer un rôle dans la prévision de leur motivation à réussir leur première année en Mathématiques. Un sondage a été mené au sein d'un panel de quatre cent-sept participants composé de deux cent-trente-trois étudiants et cent soixante-quatorze étudiantes. Un questionnaire de quarante points a été mis au point pour évaluer leur motivation et leur perception des mathématiques. L'analyse factorielle confirmatoire a soutenu l'existence d'un niveau de perception des mathématiques ainsi que quatre sous-éléments de motivation établis sur un barème (la motivation intrinsèque : pertinence/sens des mathématiques, la perception des maths, l'intérêt ou le plaisir et enfin la motivation extrinsèque : attente des résultats à venir.) Les corrélations entre la motivation, la perception et les facteurs démographiques ont indiqué, en théorie, des interactivités importantes. Les analyses de régression multiples ont permis de constater que la perception

[4] Mathematics teaching and learning (Grouws, 1992; Glanfield, 2003; Slavin, 2007). These research efforts (e.g. Reynolds & Walberg, 1991; Steinkamp & Maehr, 1983) have uncovered several factors which facilitate mathematics achievement, including student characteristics (use of learning strategies), home environment (parents as role models), and school context (teachers & quality of instruction). Among the student characteristics, motivational and emotional factors such as interest, enjoyment, or task motivation (McLeod, 1992) were also found to play a significant but indirect

des mathématiques, les données démographiques et le facteur de motivation extrinsèque sont responsables, en grande partie, des variations de motivation chez les étudiants pour réussir leur première année du programme en mathématiques. Les résultats ainsi que les répercussions dans l'enseignement et dans l'apprentissage sont argumentés en rapport avec la théorie actuelle,

INTRODUCTION

Statement of the Problem

Mathematics is an indispensable and necessary educational foundation. Despite this importance, however, there is continued evidence that Canadian students are failing to achieve a level of mathematical proficiency necessary to succeed in higher education environments (Glanfield, 2003; Slavin, 2007). First year university students are failing mathematics courses at alarming rates (Slavin, 2007). Remediation of early failure and low retention rates among this population can be financially costly. Given these perspectives, it is not surprising that much research has been devoted to identify the factors that facilitate and enhance role in mathematics achievement (Aiken, 1974; Schneider & Bos, 1985; Steinkamp & Maehr, 1983; Wilson & Palmer, 1983). For example, research findings suggest that problem solving, creativity, and deep comprehension of learning material requires high levels of positive emotions and intrinsic motivation (Csikszentmihalyi, 1988b; McLeod, 1992; McLeod & Adams, 1989; Schiefele, 1992).

The limited mathematics achievements by Canadian high school students indicate a need to investigate more deeply the motivation of first-year university students to determine whether or not they have the same levels of motivation to succeed in first-year math and how the different levels of motivation could be predicted and explained.

Research Objectives

This is important because motivated students are at an advantage both in terms of learning and performance (Artelt, 2005). Self-motivation is cited by students and teachers alike as one of the most influential aspects of student success in the university mathematics classrooms (Anthony, 2000). The motivation concept is mentioned frequently in the research literature as essential to mathematics success, but remains challenging to quantify and little has been done to investigate the main predictors of motivation. The purpose of this study is to explore some of these predictors of motivation to succeed in first-year university mathematics, namely mathematics self-concept, student demographic characteristics such as the number of mathematics courses taken, age and gender.

STUDENTS' MOTIVATION

Introduction

Research has shown that student engagement in mathematics plays a key role in the acquisition of mathematics skills and knowledge, course selection, educational pathways, and later career choices (OECD, 2005; Astin, 1968; Carnegie Commission, 1973; Sells, 1978; Sherman, 1982). The historical and contemporary underrepresentation of women in science and technology in Canada and elsewhere has long been attributed to the fact that women have tended to fear mathematics and avoid it as much as they could (Acker & Oatley, 1993; Drolet, 2001; Shapka et al, 2006).

Definition of Students' Motivation

The concept of motivation is complex and multi-faceted and has been the main focus of much of the research literature. Motivation is sometimes referred to as student motivation or academic motivation (Winn et al, 2006; Winn, 2002), teachers' motivation (Brophy, 1991), and social motivation (Winn et al, 2006).

Motivation is defined as a psychological process that imparts purpose, direction and intensity to human behaviour and consequently responsible for differential work output (Mwangi & McCaslin, 1994). Thus motivation is believed to propel and direct students to engage in academic activities, and determine how much is learned from such activities (Slavin, 1995; Tuckman, 1991). Motivation is also regarded as a psychological construct that triggers and sustains persistence and effort among individuals (Byrnes, 2003). According to Ryan and Deci (2000), motivation is the urge to do something or to undertake and accomplish an activity. In particular, motivation is also characterized as a fundamental aspect of teaching and learning in academia, hence the terms academic motivation, students' motivation, and teachers' motivation (Brewer & Burgess, 2005; Zimbardo, Weber & Johnson, 2000) and encompasses goal orientation, sustained cognitive engagement, cognitive strategies utilization, self-regulation and self efficacy (Pintrich & DeGroot, 1990; Pintrich, 2000).

This study uses the term student motivation as the disposition to pursue meaningful and worthwhile academic activities for their intended academic benefits (Brophy, 1991) and it is the interaction of several factors including learner goals, beliefs, and emotions which play a prominent role in all learning processes and may be referred to as domain-specific, such as the motivation to learn and succeed in mathematics, English, or Science (Brophy (1983, 1991).

Student motivation is thus a complex process involving an interaction of cognitive and affective factors. Motivated students have the ability to use higher cognitive processes to learn, absorb, and retain more from an academic subject (Graham & Golan, 1991). Motivated students make the effort to comprehend the subject matter, improve performance, seek challenges, and persist at tasks even in the face of failure (Woolfolk, 1990; Brophy, 1983; Good & Brophy, 1997; Slavin, 1997).

Theories of Motivation

Recent approaches to understanding student motivation are informed by a number of theories including self-efficacy theory (Bandura, 1977), attribution theory (Weiner, 1985), and self-worth theory (Covington, 1992). However, self-determination theory (Deci & Ryan, 1985) has been the most influential, which dichotomizes student motivation into intrinsic and extrinsic motivations. Intrinsically motivated students engage in an academic activity for its own sake, such as the satisfaction derived from learning mathematics (Middleton and Spanias, 1999; Ames & Archer, 1988; Dudas & Nicholls, 1992; Dweck, 1986; Lepper, 1988).

On the other hand, extrinsically motivated students engage in an academic activity for instrumental reasons, such as gaining a college degree in mathematics in order to improve employment prospects in actuary science or engineering (Deci & Ryan, 1985), good grades and teacher's approval, or to avoid punishment such as bad grades or disapproval (Ames, 1992; Ames & Archer, 1988; Dudas & Nicholls, 1992; Dweck, 1986; Vansteenkiste, Lens, & Deci, 2006). Several empirical studies have underscored the effects of extrinsic motivational factors, showing for example that more extrinsic motivation leads to greater college engagement (Skinner, Connell & Wellborn, 1990), better performance (Miserandino, 1996), less college dropping-out (Vallerand & Bissonnette, 1992), and higher quality learning (Grolnick & Ryan, 1987; Race, 1998) and *assessment systems* that foster conceptual understanding (Newstead & Hoskins, 1999). According to the self-determination theory (Ryan & Deci, 2000), both intrinsic and extrinsic motivations are needed in order to adequately foster learning and achievements in the individual (Winn et al, 2006; Deci & Ryan, 1985),

The research literature has identified several dimensions of Deci & Ryan's (1985) intrinsic motivation to learn, including interest, enjoyment, relevance, and perceived probability of success, expectancy of success or confidence, and satisfaction (Burden, 1995; Horn, 1995). These components of motivation were used in a model to study student engagement (Shernoff, Knauth, & Makris, 2000; Shernoff, Schneider, & Csikszentmihalyi, 2000). Research has shown that these factors are positively related to student engagement, which indicate that higher levels of interest, enjoyment and concentration lead to higher levels of engagement in the particular task or activity (Shernoff, Knauth, & Makris, 2000; Shernoff, Schneider, & Csikszentmihalyi, 2000; Statscan, 2004).

Self-determination theory is supported and reinforced by attribution theory (Ames & Ames, 1984; Weiner, 1979, 1984, 1985b; Wittrock, 1986). The implications of self-determination and attribution theories, as described above, are that intrinsic motivation to succeed is related to students' perceptions of themselves in relation to a particular academic subject. In addition, research findings suggest that motivational patterns as described above are learned and this learning becomes an integral part of their self-concepts (Eccles, Wigfield, & Reuman, 1987; Midgley, Feldflaufer, & Eccles, 1989; Dossey et al, 1988). This implies that, for example, motivation to learn and succeed in mathematics eventually becomes an integral part of students' mathematical self-concepts. In theory this implies that students' motivation to succeed in mathematics is rooted in the positive attitudes and feelings they develop about mathematics (Mathematics Self-Concept). It is then safe to hypothesize that students' motivation to succeed in mathematics is directly related to their mathematics self-concepts. It can thus be stated that, students with positive mathematical self-concepts are more highly motivated to study and succeed in mathematics than students with negative mathematics self-concepts. By implication, this means that any improvements in students' mathematics self-concepts will enhance their motivation to learn and succeed in mathematics.

This then begs the questions: What are students' self-concepts? And what are students' mathematics self-concepts? These questions are examined below.

STUDENT SELF-CONCEPT

Introduction

Research indicates that beliefs and perceptions about self are rooted in one's past achievement and reinforcement history (Bong & Skaalvik, 2003). Interests in these convictions about self have led to the proposition of various models and theories of self-related cognitions within the context of learning such as self-concept and self-efficacy. Self-concept is generally defined as one's general perceptions of self in a given domain of functioning (Bong & Skaavilk, 2003). On the other hand, self-efficacy is defined as the individuals' expectations and convictions of what they can accomplish in given situations. While self-concept and self-efficacy are similar in their explanatory and predictive roles in relation to motivation, emotions and achievements, they differ in the sense that whereas self-concept refers to past-oriented perceptions of the self, self-efficacy refers to future-oriented perceptions of the self (Bong & Skaalvik, 2003).

Definition of Self-Concept

Self-concept has also been defined in various other ways such as: the self-perceptions that individuals have about their academic abilities, especially their feelings and knowledge about these abilities and skills (Byrne, 1984, p. 428); the organization of qualities that the individual attributes to himself (Kinch, 1963); the sum total of the individual's thoughts and feelings having reference to himself as an object (Rosenberg, 1979); a multidimensional construct which comprises self-esteem, self-confidence, stability, and self-crystallization (Rosenberg & Kaplan, 1982), and a person's perceptions of himself which are formed through one's experiences with the environment, and influenced especially by environmental reinforcements and evaluations by significant others (Shavelson, Hubner, and Stanton, 1976, p. 411).

Shavelson et al (1976) further identified seven characteristics which are critical to the construct's definition: organized/structured, multifaceted, hierarchical, stable, developmental, evaluative, and differentiable. According to Shavelson, the general or global self-concept consists of two major categories: academic and non-academic self-concepts. The academic self concept pertains to all specific academic subjects offered in educational context, as for example English Self-Concept, History Self-Concept, Mathematics Self-Concept, and Science Self-Concept. The non-academic self-concept includes domain-specific social self-concept, emotional self-concept, and physical self-concept. Social self-concept includes peers and significant others; emotional self-concept consists of particular emotional states, and physical self-concept is made up of physical ability and physical appearance (Marsh & Shavelson, 1985).

Recent self-concept studies focusing on the domain-specific self-concepts have produced consistent results in relation to the impact of self-concept such as correlations between mathematics self-concept and achievement (Marsh, 1990d, 1993). This means to understand the direct mediating and explanatory qualities of self-concept in relation to students' motivation, it is essential to use domain-related self-concepts such as the impact of academic or mathematics self-concepts on students' motivation.

Mathematics Self-Concept

Mathematics self-concept (MSC) refers to students' evaluation of self-perceived personal possession of math skills, abilities, math reasoning ability, enjoyment, and interest in mathematics (Marsh, 1990, 1996). Students' perception of their ability in mathematics is a critical goal in itself and a means of facilitating the attainment of desirable outcomes in education, such as academic effort, persistence at tasks, selection of courses, and completion of college (Marsh, 1991, 1993). Research has underscored the positive relation between student mathematics self-concept and students' motivation to learn mathematics (Marsh, 1991, 1993).

Given this positive relationship, it is postulated that any intervention designed to improve students' mathematics self-concept would positively affect students' motivation to learn and succeed in mathematics (Hemke, 1990; Eccles et al., 1983; Nagy et al., 2010; Eccles, Wigfield, Harold, & Blumfeld, 1993; Trautwein, Ludtke, Koller, & Baumer, 2006; Nagy et al, 2006; Eccles & Wigfield, 1995; Feather, 1988; Trautwein, Ludtke, Schnyder, & Niggli, 2006; Bong & Skaalvik, 2003). Self-concept and, in particular, its domain-specific academic self-concept such as Mathematics Self-Concept, has been used to predict various outcomes including motivation, emotion, and performance (Bong & Skaalvik, 2003).

Analysis of the Empirical Literature

Motivation is a function of content, process and decision-making. Sustained interest, enjoyment and goal setting have been found to increase classroom engagement and specifically the development of mathematics- and science -related aspirations (Shernoff & Hoogstra, 2001); to account for as much as 25% of student success in first year university math courses (MacNamara & Penner, 2005); 10 percent of the variance in academic achievement (Schiefele, Krapp, & Winteler, 1992; Schiefele, Krapp, & Winteler, 1992); college grades (Shernoff and Hoogstra, 2001); prediction of mathematics grades and mathematics course level taken (Schiefele and Csikszentmihalyi, 1995; Daniels, 2008). Other research has also shown that motivation was a strong predictor of mathematics achievement (Mousoulides and Philippou 2005; Human Resources Canada, 2004).

Several empirical studies have shown that academic self-concept is not only important as a desirable outcome in itself but, more importantly, it is a potential predictor of academic motivation and performance (Bong & Skaalvik, 2003; Skaalvik & Rankin, 1996b; Skinner, Wellborn, & Connell, 1990); academic efforts (Skaalvik & Rankin, 1995); help-seeking behaviours (Ames, 1983); course selection (Marsh & Yeung, 1997b); intrinsic motivation (Gottfried, 1990; Harter, 1982; Mac Iver, Stipek, & Daniels, 1991; Meece, Blumenfeld, & Hoyle, 1988; Skaalvik, 1997b, 1998; Skaalvik & Rankin, 1996b); academic achievement (Marsh, 1992; Marsh et al, 1988; Marsh & Yeung, 1997a; Shavelson & Bolus, 1982; Skaalvik & Hagtvet, 1990; Skaalvik & Vals, 1999: Coppersmith, 1967; Butcher, 1968; Marx & Winne, 1980; O'Marley & Bachman, 1979); term grades (Choi, 2005; Lent et al, 1996); and explained 63 percent of the variance in students' motivation to learn mathematics (Githua & Mwangi, 2003).

Methodology

This section proposes analytical models and hypotheses of students' motivation and mathematics self-concept to capture and investigate the objectives of the study. It also delineates the sources of data used, sampling methods, instrumentation, that is, measurements of student motivation and mathematics self-concept. The analytical model is formally proposed and specified in the light of its assumptions and method of estimation.

Analytical Framework

The study of students' motivations is rooted in various educational and psychological theories as mentioned above. The implication of these theories is that the motivation to learn and succeed in an academic subject, such as mathematics, eventually becomes an integral part of students' mathematical self-concepts. It can thus be hypothesized that students' motivation to succeed in mathematics is directly related to their mathematics self-concepts (Shavelson, Hubner, & Stanton, 1976; Shavelson & Bolus, 1982; Marsh & Shavelson, 1985; Marsh, Byrne, & Shavelson, 1988; Marsh, 1986, 1987, 1990, 1992, 1993, 1999; Rosenberg, 1979; Bandura, 1986; Ames, 1983; Bong, 1998, 1999, 2001, 2002; Skaalvik, 1997, 1998). Based on these, an empirically verifiable functional relationship between students' motivation to succeed in mathematics and mathematical self-concept can be proposed mathematically as,

SMOT=f (MSC) (1)

However, this analytical relationship is inadequate since theoretical and empirical research has shown that students' motivation might also be potentially influenced by social and contextual factors, such as extrinsic motivational factors (Ryan & Deci, 2000). The inclusion of expectation of future income is consistent with the motivational frameworks of Eccles (e.g. Eccles et al, 1983: utility value of a task), Ford (1992: material gain), Maehr (1984: extrinsic rewards), Markus and Nurius (1986: possible selves), Nuttin (1984, 1985: time perspective), and Raynor (1974a: future orientation). In fact Eccles' expectancy-value model (Eccles & Wigfield, 1992; Wigfield & Eccles, 2000) supports the fact that many academic activities are intrinsically and extrinsically motivated. Researchers in the personal construct paradigm have made very little attempt to explicate the pertinence of extrinsic motivators to mathematics learning and success. Further research in this paradigm is therefore critical to understanding the roles of grades and other incentives such as expectation of future career and income prospects in influencing students' motivation. The following full functional relationship is therefore proposed:

SMOT =f (MSC, Extrinsic MOT, Demographic Factors) (2)

The demographic factors included in the model for purposes of estimation are gender, age, and the average number of mathematics courses taken by a student (level of math experience: Byrnes, 2003; Barnes et al, (2004).

The factor gender does not directly go into the actual estimation of the model. Since gender is either female or male, it is held as a controlling factor while the model is estimated separately for either female or male. In this way, it is possible to investigate whether there are gender differences in the effects of the independent variables on students' motivation.

Age is used to measure maturity, which is assumed to positively influence students' motivation (Didia & Hasnat, 1998). Research has shown that math grades increase with students' ages which reflect the fact that older students enter higher education with a sense of urgency and readiness to learn. Thus older students are more motivated to succeed than younger students (Gupta et al, 2006; Richardson, 1994; Trueman & Hartley, 1996; Keith, 1999). The full model can be shown as:

SMOT=f (MSC, Exp. Income, Age, Number of Math) (3)

In specific mathematical terms, the model can be specified as follows:

$$SMOT=\beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \varepsilon \quad (4)$$

Where:

SMOT = students' motivation to succeed in mathematics, the dependant or response variable

β_0 = the intercept of the equation, where SMOT equals β_0 or the mean if the X's are all zero

X_1 = mathematical self-concept

X_2 = expectation of future income

X_3 = students' ages in years

X_4 = number of mathematics courses taken by each student

β_1= effect of mathematical self-concept on students' motivation

β_2 = effect of expected future income (extrinsic factor) on students' motivation

β_3 = effect of age on students' motivation

β_4 = effect of the number of math courses taken on students' motivation

ε_i = stochastic error term included to account for the influence of probable factors not included here in the model, assumed normally distributed and homoscedastic.

X's are independent or predictor variables

β's are the coefficients or parameters to be estimated from the model which indicate the strength of association between the X's and SMOT, or measure the effect of each of the independent variables on students' motivation to succeed in mathematics

Model's Assumptions

The model is based on the following classical linear regression assumptions (Greene, 2007; Baum, 2006): error terms are normally distributed with mean zero and constant variance: $\varepsilon_i \sim N\ [0, \sigma^2 I]$

Model's Hypotheses

The following hypotheses concerning the model are made: ($\beta_1>0$; $\beta_2>0$; $\beta_3>0$; $\beta_4>0$). These hypotheses about the model's coefficients reflect the hypotheses the study is designed to investigate and which were stated in a previous section.

Data Collection and Instrumentation

In order to estimate the model and use the estimated results to test all the hypotheses postulated above, concerted efforts were made by the researcher with the help of mathematics instructors to collect survey data about students' motivation to succeed in college mathematics and mathematical self-concept at various post-secondary institutions in Alberta.

The students who responded completed two types of 40-item instrument compiled from various sources and supplemented with items designed by the researcher (Motivated Strategies for Learning Questionnaire, Pintrich, Smith, Garcia, & McKeachie, 1991) and Intrinsic Motivation Inventory (IMI, Ryan, 1982; Ryan, Mims, & Koestner, 1983; Plant & Ryan, 1985; Ryan, Connell & Plant, 1990; Ryan, Koestner, & Deci, 1991; Deci et al, 1994). For the students motivation construct, only 24 items adequately measuring the following motivational subscales were included: interest and enjoyment; perceived probability of success; relevance/usefulness of mathematics; and extrinsic motivational factor (expectation of future income).

All the items used a 5-point Likert-type format. The Likert scales were anchored with the following statements: "strongly disagree (1)" to "strongly agree (5)". The items on the instrument were a combination of previously validated items and new ones designed purposely for this research project. The distribution of the items by the motivational subscales is shown in Table 1 below.

There are 16 items on the mathematical self-concept construct (Table 2) which were compiled from previously validated scales such as the Self Description Questionnaire (SDQ; Marsh & O'Neil, 1984) which is considered one of the best self-concept instruments available (Byrne, 1996; Marsh, 1990, 1993; Marsh & Craven, 1997); Attitude Toward Math Inventory (ATMI, Fennema & Sherman, 1976). The ATMI is known to possess sound psychometric properties and has been used in research over the last several decades (Tsao, 2004).

Table 1: Distribution of Items on Motivational Subscales

	Items Distribution	
Subscale	#	%
Essential/Relevance of Mathematics	7	29.2
Students' Perception of Mathematics	10	41.7
Interest and Enjoyment of Mathematics	6	25.0
Expectation of Future Income (Extrinsic Factor)	1	4.2
Total	24	100.0

Table 2: Distribution of Items on Mathematics Self-Concepts

	Items Distribution	
Subscale	#	%
MSC	16	100

Subscale Reliabilities and Items' Descriptive Statistics

Although the items on the instrument were previously validated items and had been used in several research projects before as mentioned above, attempts were made to determine whether the motivation subscales items loaded onto separate factors as previous results had shown. Maximum Likelihood factor analysis with a Varimax (orthogonal) rotation was performed. Factor analysis is a method used to examine interrelationships among a number of variables with minimal loss of information. Six factors with Eigen values greater than one emerged. As expected, the four motivational subscale items loaded onto their own factor with loadings of 0.45 or greater. In addition, all of the self-concept items loaded on two factors with loadings of 0.45 or greater. The factor analysis was done for confirmatory purposes for the current research since the items were compiled from related actual subscales.

To determine subscale internal consistencies and reliabilities, the Cronbach alpha reliability coefficients were computed for both the motivation and mathematical self-concept subscales. These are shown in Table 3 and Table 4. As can be seen in Table 4, coefficients for the motivation subscales of Essential & Relevance, Perception, and Interest& Enjoyment subscales ranged from 0.65 to 0.85, all indicating acceptable internal consistencies and reliabilities for the item scores. As can also be seen in Table 5, coefficients for the mathematical self-concept ranged from 0.58 to 0.79, all indicating acceptable internal consistencies and reliabilities of the item score.

Measures of Students' Motivation and Mathematical Self-Concept

For analytical purposes, the mathematical self-concept was defined as a composite variable represented by the mean scores of students' responses on the 1-5, 16 items scale. Examples of this measurement of students' mathematical self-concept abound in the empirical literature (Chouinard,et al, 2007).

Students' motivation to succeed in mathematics was operationally defined as a composite measure represented by the mean scores of students' responses to the 1-5, 24 items scale that adequately covered the four subscales of students' motivation to succeed in mathematics: essential & relevance of mathematics; perception of mathematics; interest & enjoyment of mathematics; and expectation of future reward (extrinsic motivation). The decision to combine the subscales (relevance & significance of math; perception of math; interest & enjoyment of math) into a single composite measure of students' motivation was based on their positive inter-correlations (r_{sp}=0.2944; r_{si}=0.3448; r_{ip}=0.2000) and the fact that prior factor analyses have shown that they have high loadings on the same factor (Jackson, 1984).

Examples of this measurement of students' motivation abound in the research literature (Ryan, 1982; Harrackeiewicz, 1979; Harter, 1981; Ferrer-Caja & Weiss, 2000; Pintrich & DeGroot, 1990; Schiefele & Csikszentmihalyi, 1995; Stevens et al, 2004).

Table 3: Cronbach ✔ Reliabilities for the Students' Motivation Subscales

	Test Scale	
Motivational Subscales	**Average Inter-Item Covariance**	**Alpha (α)**
Essential and Relevance of Math	0.2186597	0.6477
Perception of Math	0.1483270	0.6453
Interest and Enjoyment	0.6806938	0.8530
Total: Students' Motivation	0.1553384	0.7909

Table 4: Cronbach α Reliabilities for the Mathematical Self-Concept

	Test Scale	
Mathematical Self-Concept Subscales	**Average Inter-Item Covariance**	**Alpha (α)**
MSC	0.2182583	0.7911

ANALYSIS OF FINDINGS

Introduction

This section presents analyses of the results from the estimated models and other statistical analyses conducted to investigate the research questions. The section first presents the descriptive statistics of the variables used to estimate the analytical models and then performs diagnostic checks on the model's specification with respect to any violation of the classical linear regression assumptions. These are followed by analyses of the inter-correlations between the variables. Last but by no means the least the section presents a comprehensive analysis of the regression models to investigate the functional relationship between the dependant variable and the independent variables in the model. The findings of previous empirical work are cited to support the findings in this study.

Diagnostic Checking (Evaluating the Assumptions of the Model)

The estimated model was subjected to diagnostic checking to determine any model misspecification errors that might undermine the interpretation of the estimated results as well as use of the results to make inferences.

The underlying assumptions of the specified model are the assumptions of the classical linear regression model: independence and normally distributed residuals, homoscedastic and serially uncorrelated: $\varepsilon_t \sim N\ [0, \sigma I]$. The diagnostic tests therefore included the normality test of the residuals, the Breusch-Pagan / Cook-Weisberg test for heteroscedasticity, and the variance inflation factor (VIF) for multicollinearity. The overall diagnostic tests did not result in any strong evidence of model misspecification. It can therefore be safely assumed that the model was correctly specified and the estimated parameters are sound and can be used for inferential purposes. However, the results, analysis and conclusions must be interpreted with caution as we might not have been able to foresee or uncover all the model's misspecification errors. In addition, there are solid guarantees for validity of the data used.

Relationship between Student Motivation and Math Self-Concept

The major focus of this research was to test the hypothesis that mathematics self-concept is a significant predictor of students' motivation to succeed in first year college mathematics. To test the hypothesis, the proposed regression model for the entire sample. The results are presented in Table 5. As shown in Table 4, mathematics self-concept (MSC) was a positive and statistically significant predictor of students' motivation (SMOT) to succeed in first-year college mathematics (β=0.49693, t=16.83, p<0.001), accounting for 41.2% of the variance in students' motivation (F (1, 405) =283.220, p<0.001; RMSE=0.301). The adjusted R^2(41.0%) indicates that only 0.2% of the variance explained was due to chance.

The correlation coefficient (R=0.642) indicates that students' motivation was very strongly correlated with mathematics self-concept. The standardized beta coefficient (standardized-β=0.64151) indicates that the effect of mathematics self-concept on students' motivation to succeed in mathematics was very strong. This result is consistent with Shavelson et al (1976) and Nwangi & Githua (2003) who noted that self-concept is important as both an outcome and as a mediating variable that helps to explain other outcomes. In this case, mathematics self-concept is helping to explain the variance in students' motivation to succeed in first-year college mathematics. Similarly, empirical research has shown that mathematics achievement is substantially correlated with math self-concept (Marsh, Byrne, & Shavelson, 1988; Bandura, 1986; Skaalvik and Rankin (1995).

To explore gender differences in terms of the effect of MSC on SMOT, the model was estimated for male students, first holding female constant and, secondly, holding male students constant. The results are shown in Table 6 (Male) and 7 (Female). As can be seen in the Tables, both equations performed very well, although the female R^2 (0.43) was slightly greater than the male R^2 (0.39). In addition, the effect of mathematics self-concept on students' motivation was stronger for females (standardized-b=0.65462) than males (standardized-b=0.62443), indicating slight gender differences in terms of the effect of MSC on SMOT.

Table 5: Relationship between Student Motivation and Mathematics Self-Concept (T)

Variables	Estimated Coefficient	Standard Error	t-Value	Sign p>|t|	Standard B
Constant	1.815*	0.096	18.80	0.000	
Math Self-Concept (All)	0.497*	0.029	16.83	0.000	0.642
R-square	0.412				
Adjusted R-square	0.410				

Correlation R	0.642
Root Mean Square Error (RMSE)	0.301
F (1, 405)	283.220 p>F = 0.000
* Significant at p<0.01; **Significant at p<0.05	

Table 6: Relationship between Student Motivation and Mathematics Self-Concept (M)

Variables	Estimated Coefficient	Standard Error	t-Value	Sign p>|t|	Standard B
Constant	1.827*	0.135	13,57	0.000	
Math Self-Concept (M)	0.495*	0.041	12.15	0.000	0.624
R-square	0.390				
Adjusted R-square	0.387				
Correlation R	0.624				
Root Mean Square Error (RMSE)	0.293				
F (1, 231)	147.640 p>F = 0.000				
* Significant at p<0.01; **Significant at p<0.05					

Table 7: Relationship between Student Motivation and Mathematics Self-Concept (F)

Variables	Estimated Coefficient	Standard Error	t-Value	Sign p>|t|	Standard B
Constant	1.809*	0.141	12,86	0.000	
Math Self-Concept (F)	0.496*	0.044	11.36	0.000	0.655
R-square	0.428				
Adjusted R-square	0.425				
Correlation R	0.654				
Root Mean Square Error (RMSE)	0.313				
F (1, 172)	128.97 p>F = 0.000				
* Significant at p<0.01; **Significant at p<0.05					

Relationship between SMOT & MSC, Demographic and Extrinsic Factors

Two of the research questions were: Is there a significant relationship between students' motivation to succeed in first year college mathematics and students' demographic characteristics such as age, gender, and the number of mathematics courses taken? Is there a significant relationship between student motivation to succeed in first year college mathematics and expectation of future income?

To answer these questions or test the hypotheses, a comprehensive model was proposed above which regressed students' motivation on MSC, expectation of future income, age, and number of mathematics taken. This model was first estimated for the whole sample, then for male students controlling the female students, and then for female students controlling male students. The estimated results are presented in Tables 8-10 below.

As suggested above, several goodness of fit indices were used to evaluate this comprehensive model (Table 8). The model provided a strong fit to the data, as measured by the R^2 =0.468, adjusted-R^2 =0.463, the very low RMSE=0.287, and the large F-value (88.33, p>F = 0.000, significant far beyond 0.001, that is p<0.001). The estimated R (0.684) indicates that the dependent variable, SMOT, is very strongly correlated with the independent variables as a whole. The R^2 value (0.468) implies that the model explained 46.8% of the variance in students' motivation to succeed in first-year university mathematics.

In addition, the model diagnostic tests did not indicate serious misspecification errors. All the model's effects (β's) were statistically significant at 0.01 (or 0.05, 0.10) levels as indicated by their t-values and p-values (probability of significance) and are consistent with a priori expectations. This indicates that MSC ($\beta=0.446$, $p<0.05$), future income (extrinsic factor, $\beta=0.085$, $p<0.05$), age ($\beta=0.008$, $p<0.05$) and number of mathematics taken (math experience, $\beta=0.016$, $p<0.10$) are all significant predictors of students' motivation to succeed in first-year college mathematics.

It was posited above that the standardized beta coefficient (b) represents the estimated average change in standard deviation units and indicates the strength of the effect of each independent variable on the dependent variable (Baum, 2006). Based on this, it can be said that the MSC (b=0.576) has the strongest predictive effect on students' motivation to succeed in first year college mathematics, followed by expectation of future income (b=0.222).

To explore gender difference, the model was estimated separately for male and female students. The results are shown respectively in Tables 9 and 10 below.

On the whole, both equations fitted the data very well as the full sample model. For male students, MSC ($\beta=0.448$, $p<0.05$), expectation of future income ($\beta=0.075$, $p<0.05$), and age ($\beta=0.012$, $p<0.05$) were statistically significant predictors of male students' motivation to succeed in first-year college mathematics. However, number of mathematics measuring math experience ($\beta=0.006$, $p>0.05$) was not a statistically significant predictor of male students' motivation to succeed in first year college mathematics, implying that for male students in this sample, math experience did not matter.

For female students (Table 10), MSC ($\beta=0.439$, $p<0.05$), expectation of future income ($\beta=0.098$, $p<0.05$), and math experience (number of math courses taken, $\beta=0.039$, $p<0.05$) were statistically significant predictors of female students' motivation to succeed in first-year college mathematics. However, age ($\beta=0.005$, $p>0.05$) was not a statistically significant predictor of female students' motivation to succeed in first-year college mathematics, implying that for female students in this sample, age did not matter.

In addition, the results indicate that the strongest predictor of male students' motivation while holding females constant was MSC (standardized b=0.564), and the strongest predictor of female students' motivation while holding male students constant was also MSC (standardized b=0.579). Another important finding is that expectation of future income (extrinsic motivation, standardized b=0.240) was a stronger predictor of female students' motivation than male students' motivation (standardized b=0.206). And among the three estimated equations, the female equation performed better than the male and the whole sample equations, with highest R^2 (0.502) and R (0.709). These gender differences are significant findings and are discussed further below.

Table 8: Relationship between SMOT, MSC, Demographic & Extrinsic Factors (T)

Variables	Estimated Coefficient	Standard Error	t-Value	Sign p>|t|	Standard B
Constant	1.471*	1.269	11.59	0.000	
MSC	0.446*	0.029	15.14	0.000	0.576
Future Income (Ext M)	0.085*	0.014	5.84	0.000	0.222
Age	0.008**	0.004	2.00	0.047	0.073
# of Math Courses	0.016	0.010	1.62	0.106	0.059
R-square	0.468				
Adjusted R-square	0.463				
Correlation R	0.684				
Root Mean Square Error (RMSE)	0.287				
F (4, 402)	88.33 p>F = 0.000				
* Significant at p<0.01; **Significant at p<0.05					

Table 9: Relationship between SMOT, MSC, Demographic & Extrinsic Factors (M)

Variables	Estimated Coefficient	Standard Error	t-Value	Sign p>|t|	Standard B
Constant	1.444*	0.175	8.24	0.000	
MSC	0.448*	0.041	10.92	0.000	0.564
Future Income (Ext M)	0.075*	0.019	4.00	0.000	0.206
Age	0.012**	0.006	2.01	0.046	0.101
# of Math Courses	0.006	0.012	0.52	0.606	0.026
R-square	0.440				
Adjusted R-square	0.430				
Correlation R	0.663				
Root Mean Square Error (RMSE)	0.282				
F (4, 228)	44.77 p>F = 0.000				
* Significant at p<0.01; **Significant at p<0.05					

Table 10: Relationship between Motivation, MSC, Demographic & Extrinsic Factors (F)

Variables	Estimated Coefficient	Standard Error	t-Value	Sign p>|t|	Standard b
Constant	1.479*	0.187	7.91	0.000	
MSC	0.439*	0.043	10.22	0.000	0.579
Future Income (Ext M)	0.098*	0.023	4.22	0.000	0.240
Age	0.005	0.006	0.89	0.374	0.048
# of Math Courses	0.039**	0.019	2.04	0.042	0.111
R-square	0.502				
Adjusted R-square	0.490				
Correlation R	0.709				
Root Mean Square Error (RMSE)	0.295				
F (4, 169)	42.55 p>F = 0.000				
* Significant at p<0.01; **Significant at p<0.05					

Variable Inter-Correlations

The regression analyses above afforded an opportunity to examine the relationship between the dependent variable (students' motivation) and the independent variables in the sample, as well as how the independent variables added to the explanation of variance in the dependent variable. One of the research questions was: are there significant correlations between student mathematics self-concept and student age, gender, and the number of mathematics courses taken, as well as the SMOT and MSC subscales? This section uses the Pearson Product Moment Correlations to examine the simple correlations among the variables in this study in order to illuminate how the independent variables interact to predict the dependent variable. The computed correlations for the whole sample are shown in Table 11 below.

As shown in Table 11, there were modest but significantly positive correlations among the students' motivation subscales: significance/usefulness & perception of math ($r=0.2591$, $p<0.001$); significance/usefulness & interest/enjoyment ($r=0.2117$, $p<0.001$), indicating that these three subscales reinforce one another in their determination of the overall students' motivation to succeed in first-year college mathematics. Appreciating the significance/usefulness of math is probably helpful in one's favourable perception of math, as well as enhancing the interest/enjoyment one derives from math.

There was a significant and positive correlation between two intrinsic motivation subscales and the extrinsic motivation subscale (expectation of future income): significance/usefulness & expectation of future income ($r=0.4161$, $p<0.001$), and interest/enjoyment of math & expectation of future income ($r=0.2810$, $p<0.001$), implying that extrinsic motivation is a potential predictor of significance/usefulness of math and interest/enjoyment in math. Expectation of future income was not significantly correlated with perception of math, implying no relationship between extrinsic motivation and this motivation subscale. The perception of math subscale as defined in this study was somewhat vague and failed to elicit the appropriate responses from the students in the sample such as would correlate with the expectation of future income. On the other hand, the modest but statistically significant correlations between subscales significance/usefulness of math and interest/enjoyment of math & extrinsic motivation subscale indicate that extrinsic motivation enhances and reinforces the effectiveness of these subscales to determine the overall students' motivation to succeed in first-year college mathematics. Students who understand the significance/usefulness of mathematics and derive interest/enjoyment in pursuing it would be more interested in the expectation that their success would put them in excellent career paths with promising prospects, including income.

An important finding of this study is the very strong and statistically significant correlation between MSC and students' motivation ($r=0.6415$, $p<0.001$), indicating that students' motivation to succeed in first-year college mathematics is very strongly related to their mathematical self-concept (MSC).

To explore the possibility that different patterns of intercorrelation might exist for males and females, separate correlation matrices were computed and tested for significant differences between the strength of the correlations found for males and females (Ferguson, 1971). These matrices are shown in Tables 12 & 13 respectively for males and females. Overall the patterns of intercorrelation seemed to be quite similar for males and females, with none of the differences being statistically significant at the 0.001 level.

However, there were a couple of minor gender differences which have already been highlighted in the regression analysis. For example, among male students, there was a statistically significant correlation between age and math experience ($r=0.1603$, $p<0.05$) whereas among female students there was no significant correlation between age and math experience ($r=0.0013$, $p>0.05$). Among male students, age significantly correlated with significance/usefulness of math ($r=0.1633$, $p<0.05$) and perception of mathematics ($r=0.1797$, $p<0.01$), whereas among female students, age was only significantly correlated with perception of math ($r=0.1889$, $p<0.05$). Another important gender difference is that among male students, age was slightly significantly correlated with students' motivation ($r=0.1216$, $p<0.06$) whereas among female students, age was not significantly correlated with students' motivation ($r=0.0490$, $p>0.05$), implying that age is significant to male students' motivation, whereas age is not significant to female students' motivation, to succeed in first-year college mathematics. On other hand, math experience did not significantly correlate ($r=0.0185$, $p>0.01$) with male students' motivation to succeed in first-year college mathematics, whereas math experience significantly correlated ($r=0.1809$, $p<0.01$) with female students' motivation to succeed in first-year college mathematics. This implies that math experience is significant among female students whereas math experience is not significant among male students in the sample, although recent research shows that previous mathematics experience is an important factor irrespective of gender (Wheeler & Montgomery, 2009).

Table 11 Inter-Correlations of Students' Motivation Subscales, MSC & Demographics

	SMOT	Usefulness Of Math	Perception Of Math	Interest & Enjoyment	MSC	Future Income	Age	No. Math Taken
SMOT	1.0000							
Use of Math	0.6981* 0.0000	1.0000						
Per of Math	0.5943* 0.0000	0.2591* 0.0000	1.0000					
Int. & Enjoy	0.7325* 0.0000	0.2117* 0.0000	0.1106* 0.0256	1.0000				
MSC	0.6415* 0.0000	0.3530* 0.0000	0.1977* 0.0001	0.6726* 0.0000	1.0000			
Future Income	0.3925* 0.0000	0.4161* 0.000	0.0792 0.1107	0.2810* 0.0000	0.2895* 0.0000	1.0000		
Age	0.0862 0.0826	0.0890 0.0729	0.1814* 0.0002	-0.0501 0.3133	0.0082 0.8692	0.0123 0.8042	1.0000	
No. of Math	0.0846 0.0883	0.0780 0.1163	0.0601 0.2265	0.0401 0.4197	0.0152 0.7601	0.0431 0.3859	0.0969 0.0507	1.0000

Table 12: Inter-Correlations of Students' Motivation Subscales, MSC & Demographics (Male)

	SMOT	Usefulness Of Math	Perception Of Math	Interest & Enjoyment	MSC	Future Income	Age	No. Math Taken
SMOT	1.0000							
Use of Math	0.6684* 0.0000	1.0000						
Per of Math	0.6221* 0.0000	0.2717* 0.0000	1.0000					
Int. & Enjoy	0.6654* 0.0000	0.0891 0.1754	0.0722 0.2726	1.0000				
MSC	0.6244* 0.0000	0.3212* 0.0000	0.2098* 0.0013	0.6313* 0.0000	1.0000			
Future Income	0.3621* 0.0000	0.4029* 0.0000	0.0727 0.2689	0.2210* 0.0007	0.2789* 0.0000	1.0000		
Age	0.1216 0.0638	0.1633* 0.0126	0.1797* 0.0060	-0.0665 0.3118	0.0344 0.6017	-0.0141 0.8306	1.0000	
No. of Math	0.0185 0.7793	0.0343 0.6029	0.0403 0.5401	-0.0279 0.6714	-0.0377 0.5668	-0.0117 0.8592	0.1603* 0.0143	1.0000

Table 13: Inter-Correlations of Students' Motivation Subscales, MSC & Demographics (Female)

	SMOT	Usefulness Of Math	Perception Of Math	Interest & Enjoyment	MSC	Future Income	Age	No. Math Taken
SMOT	1.0000							
Use of Math	0.7357* 0.0000	1.0000						
Per of Math	0.5992* 0.0000	0.2944* 0.0001	1.0000					
Int. & Enjoy	0.8029* 0.0000	0.3449* 0.0000	0.1949* 0.0099	1.0000				
MSC	0.6546* 0.0000	0.3769* 0.0000	0.2153* 0.0000	0.7107* 0.0000	1.0000			
Future Income	0.4163* 0.0000	0.4001* 0.0000	0.1440 0.0579	0.3303* 0.0000	0.2811* 0.0002	1.0000		
Age	0.0490 0.5212	0.0002 0.9975	0.1889* 0.0126	-0.0324 0.6714	-0.0182 0.8116	0.0453 0.5525	1.0000	
No. of Math	0.1809* 0.0169	0.1271 0.0948	0.1373 0.0708	0.1319 0.0828	0.0774 0.3100	0.1010 0.1847	0.0013 0.9866	1.0000

Definition of Acronyms used:
SMOT=Students' Motivation
AMSC=Affective Mathematics Self-Concept
CMSC=Cognitive Mathematics Self-Concept
TMSC=Total Mathematics Self-Concept
#Math=Number of mathematics taken

Conclusions, Limitations and Recommendations

This study has shown that mathematics self-concept is a significant predictor of students' motivation to succeed in first-year college mathematics. It has also shown that motivation to achieve in mathematics is not solely a product of mathematical self-concept variables such as mathematics ability, competence, efforts, and self-confidence, nor is it so stable that intervention programs cannot be designed to improve it. Instead the motivation to achieve in mathematics is highly influenced by demographic factors such as age, gender, and mathematics experience.

One of the limitations of the study pertains to the fact that it was limited in its coverage since the institutions are based in the province of Alberta, making the results of the study not generalizable to students across the country. Replications based on more representation samples across Canada are needed to provide broader perspectives in order to make the findings generalizable.

The results of the study support the conceptual relationship between mathematics self-concept and students' motivation to achieve in mathematics. Further studies could attempt to replicate these results with students from other provinces in Canada and at different educational levels. Finally, the next logical step would be to evaluate the predictive utility of the mathematical self-concept and students' motivation by adding academic achievement measures in the research investigation.

Future research may also investigate more closely the differential impacts of significant others on students' motivation and mathematics achievement. For example, on the basis of this study, it is treasonable to hypothesize that significant others (parents, teachers, peers) may substantially affect students' motivation to achieve in mathematics through the sorts of facilitating conditions identified in the qualitative data. The Parent, Teacher, and Peer scales in the Facilitating Conditions Questionnaire (FCQ, McInerney, Dowson, & Yeung, 2005) may allow researchers to identify which sources of influence from significant others may most influence students' motivation and mathematical self-concept.

The extrinsic motivation measure used in the study was based on a single item. Although the study has provided some evidence for its validity, it seems desirable for future studies to include a more differentiated and reliable measure that tries to capture a student's perceived value of mathematics achievement and the motivation to succeed.

The study has shown that ability perceptions have impact on students' motivation to succeed in mathematics through its mediating influence on mathematical self-concept. Meece and her colleagues (1990) have also shown that ability perceptions have a strong impact on value perceptions (such as interest). Therefore, future research should include not only test-based indicators of ability but also measures of perceived competence or ability. In fact, separating mathematical self-concepts into its varied perceived elements will enable exploration of correlational analysis between them and the individual motivational elements.

In summary, it is believed that future efforts of this type may profit from an even broader purview that included systematic collection of self-report data on the motivational thinking of both the instructors and the students; broader and more fundamental assessment of the target students' educational needs, which would include attention to both the value and expectancy aspects of students' motivation to achieve in mathematics.

On the whole the findings provide valid empirical evidence for the importance of considering mathematics self-concept in models of students' motivation to succeed in mathematics. Students' motivation to succeed in mathematics is closely related to students' self-perceptions of their ability and competence to succeed in mathematics. At the same time, demographic factors, extrinsic motivational factors, as well as home and college environmental factors are implicated in students' motivation to engage with the educational process and to succeed in first-year college mathematics. Although extensive research effort has been invested in disclosing the nature of relationship between students' motivation and their mathematics achievement, self-concept influences on students' motivation, which is presumably responsible for different levels of motivation to learn and succeed have been ignored. Herein lay the modest contribution that this study makes to the motivation and self-concept literature. Research on students' motivation will surely benefit from the contributions made by this study.

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