The relationship between variables that represent motivation and achievement in post-secondary mathematics

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Ethics Statement

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Abstract

This dissertation consists of a theoretical study and three empirical studies. The theoretical study addressed the question of how to constitute a motivation questionnaire for investigating the relationship between motivation and academic achievement. The dissertation argued that for a consistent questionnaire, we must turn to the properties of variables. Using object properties, this dissertation classified achievement variables into three categories: motivators, mediators, and moderators and proposed a moderated-mediation model (Hayes, 2013) as a framework for investigating the relationship between motivation and academic achievement. Intrinsic and extrinsic motivation were classified as mediators, while self-efficacy belief, self-determination and anxiety about mathematics were classified as moderators of academic achievement.

The proposed framework was implemented through a mediation and a moderated-mediation analysis. With motivation as predictor, academic achievement as outcome, and intrinsic or extrinsic motivation as mediating variables, this dissertation imagined a mediation path diagram (Baron & Kenny, 1986) as a triangle of vectors in equilibrium, and argued that the feasibility of mediation implicitly assures the feasibility of reverse mediation; that suppression might be interpreted as reverse mediation (study 2).

With mathematics self efficacy belief as a dependent variable, a stepwise multiple regression showed that pride, academic interest, academic achievement goals and hope accounted for 62.2% of variance in mathematics self-efficacy belief. A discriminant anlaysis showed that pride, academic interest, and academic achievement goals discriminates between students with low and high mathematics self-efficacy beliefs. With both results, this dissertation argued that motivation variables might be the drivers of persistence often associated with strong self-efficacy belief; that persistence might be a reflective indicator of motivation (study 3).

The goal of empirical study 1 was to determine the set of indicators that accounts for most variance in a student's academic achievement. This goal was not realized perhaps due to unexpected poor correlation statistics between the indicators of motivation and student's final grades as observed in this dissertation. This dissertation concludes that both the proposed and related research frameworks may only be used to compare groups of students, rather than individual students (Bandura, 2001).

Keywords: motivators; mediators, moderators; mediation and moderated-mediation; reverse mediation; motivating property

Dedication

To the memories of my brother

Alexander Udevi-Aruevoru

and my father

Joseph Egwuonwu Udevi-Aruevoru

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Chapter 1.

Introduction

> A college degree is key to economic opportunity, conferring substantially higher earnings on those with credentials than those without (Carnevale, Rose, & Cheah, 2013, p.1)

In the same report Carnevale, et al. (2013) wrote that a Bachelor's degree holder has a lifetime earnings of about $2.7 million more than a person with a high school education; that even amongst those in the same occupation, more education often means more money. For example, truck drivers without a high school education earn substantially less than those with a high school education; elementary and middle school teachers with a Master's degree have a life time earnings of about $2.2 million compared to $1.8 million for those without a Master's degree.

The connection between one's level of education, family income, social status, and overall health in her family is evident across many cultures. For many people, education is a vehicle for upward social mobility, often the quickest way of lifting families out of poverty. In this sense, education might be perceived as an economic activity, an investment made by students and their families. It is also for this investment that many students travel thousands of miles to distant lands to pursue a good education. For all of the above reasons, as we inquire into the relationship between variables that represent motivation (indicators of motivation) and achievement in post-secondary mathematics, we should be mindful of why students are in school in the first place. Because, one's reason for making the required investments in time, money, and years of delayed gratification might offer helpful insights on her motivation for academic achievement (Nolen, 1996; Gamboa, Rodriguez, & Garcia, 2013).

In this chapter, I will review the state of current research on motivation and academic achievement and point out some of its challenges. I will argue that a theoretical framework for investigating the relationship between motivation and academic achievement should include the following categories of variables: motivators, mediators and moderators. I will end this chapter by sketching possible role(s) that these variables might play in a student's quest for academic achievement and why they are required components of such a theoretical framework.

1.1. The research on motivation and academic achievement

Quantitative research on the relationship between motivation and academic achievement is based on the premise that we could use a student's motivation to predict her academic achievement. Implicitly, this suggests a proportional relationship between motivation and academic achievement. Research on motivation and academic achievement is currently pursued through two main research frameworks. The first, with motivation questionnaires and through a direct and assumed linear relationship between motivation and academic achievement (Glynn & Koballa, 2006). The other, by investigating the relationship between different indicators of motivation with academic achievement. Self-efficacy belief is one such indicator that has featured prominently in many of these studies. The following statements evidence the importance of self-efficacy belief on academic achievement.

> How people behave can often be better predicted by their beliefs about their abilities than by what they are actually capable of accomplishing, for these beliefs help determine what individuals do with the knowledge and skills they have (Pajares & Miller, 1994, p. 193)

Also, Beghetto and Baxter, (2012, p. 942) put this succinctly when they wrote the following:

> ability alone is not sufficient. Students who otherwise have the ability to be successful in learning science and math, yet believe they are not capable of success, likely give up in the face of challenge, under perform, and ultimately, focus their effort and attention on other pursuits and endeavors. Put simply: 'student's beliefs matter'

Other studies on the impact of different indicators of motivation on academic achievement include the following: Glynn and Koballa (2006), Nolen (1996), Koller, Baumert and Schnabel (2001), Cano and Berben (2009), and Harackiewicz, Durik, Barron, Linnenbrink-Garcia and Tauer (2008), investigated the impact of students' academic interests and academic achievement goals on academic achievement. Pekrun, Frenzel, Goetz and Perry (2007), Pekrun and Stephens (2009), Pekrun, Goetz, Frenzel, Barchfeld and Perry (2011), Villavicencio and Bernardo (2012) used the control value theory of achievement emotions to argue that enjoyment, hope, pride, anger, anxiety, shame, hopelessness and boredom emotions might impact a student's academic achievement. They argued that hope, anticipatory pride, and other perceived benefits of academic achievement may compel one to take a positive view and strive harder with respect to a learning activity that they might otherwise perceive as difficult for them. Further, they argued that enjoyment, hope and pride are positive emotions with each positively correlated with academic achievement. Hull-Blanks, Kurpius, Befort, Sollenberger, Nicpon and Huser (2005) investigated the impact of one's future career goals and aspirations as motivators for learning.

For quantitative research on the relationship between motivation and academic achievement using motivation questionnaires, the indicators of motivation used in these questionnaires are those that are deemed to measure a students' motivation for academic achievement. However, after several decades of research, these studies have met with limited progress. There appears to be a lack of agreement on how to constitute the motivation questionnaire used in these studies. For example, the Science Motivation Questionnaire (Glynn & Koballa, 2006) consists of six subscales representing the following indicators: intrinsic motivation, extrinsic motivation, self-determination, self-efficacy belief, personal relevance of learning science, and anxiety about science assessment. Here, and elsewhere in the literature (Schunk, et al., 208, p. 236), intrinsic and extrinsic motivations are represented as different methods of learning or, as different reasons for learning. The expectation is that a student may use one or the other but, not both for an activity. The simultaneous use of both variables for an activity is not defined in the literature. Thus, by definition both variables are mutually exclusive. Versions of this instrument exist as Biology Motivation Questionnaire, Chemistry Motivation Questionnaire, and Physics Motivation Questionnaire where the word science was simply changed to biology,

chemistry and physics, respectively (Glynn, Brickman, Armstrong & Taasoobshirazi, 2011)

Bryan, Glynn, and Kittleson (2011) in their investigation of the motivation of high school students to learn science, used a three-component motivation questionnaire that consisted of intrinsic motivation, self-efficacy belief and self-determination. In that study, they also solicited student essays on their motivation to learn science and followed by an interview of a sample of the students. Kim, Park and Cozart (2012) in their investigation of factors that impact students' mathematical achievement in an online learning environment used a motivation questionnaire that consists of self-efficacy belief, intrinsic motivation, and the following achievement emotions: boredom, anxiety, enjoyment, anger, shame, pride and hopelessness, as indicators of motivation. The Motivated Strategies for Learning Questionnaires (Pintrich & de Groot, 1990) consists of self-efficacy belief, intrinsic value, test anxiety, self-regulation, and cognitive strategy use.

In each of the studies referenced above, the motivation questionnaires differ both in the number and the composition of the indicators of motivation. This lack of agreement on how to constitute a questionnaire for investigating the relationship between motivation and academic achievement, might account for the conflicting statements on the impact of different indicators of motivation on academic achievement (Pajares & Miller, 1994; Kim, et al., 2012). Also, we lack a legitimate basis for comparing the results from different studies. Hence, this question:

> How should we constitute a motivation questionnaire for investigating the relationship between motivation and academic achievement?

From this literature review and with respect to achievement in post-secondary mathematics, the following eleven indicators of motivation are frequently cited as important factors: intrinsic motivation, extrinsic motivation, personal relevance of learning mathematics, self-determination, mathematics self-efficacy belief, anxiety about mathematics assessment, hope, pride, student's academic interest, student's academic achievement goals, and the importance of mathematics to future career goals of each student. In the research literature, each of these variables is treated as a different indicator

of motivation for mathematics achievement. Each is expected to account for different aspects of a student's motivation for academic achievement.

With respect to the eleven indicators of motivation identified in this dissertation (above), a possible reason for conflicting reports on the impact of each indicator on academic achievement might be because these indicators have different degrees of correlation with each other. The large number of their possible configurations in a multivariate analysis may account for the reported differences on the impact of each when used in the absence of others. This suggests that a piecemeal approach (Pajares & Miller, 1994; Kim, et al, 2012) to investigating the relationship between the indicators of motivation and mathematics achievement may not be adequate. A full understanding of their collective and separate impact on academic achievement requires that all indicators be investigated together.

The academic achievement variable (outcome variable) used in many of these studies is usually a student's final grade in an assigned mathematics course or her cumulative grade point average (GPA). These variables are different measures of similar constructs. Thus, each, is a reflective indicator of academic achievement, and expected to be strongly correlated with each other.

From this literature review, this dissertation argues that to advance our knowledge of the relationship between motivation and academic achievement, we need to know the specific roles(s) and contribution of each indicator in a motivation questionnaire to academic achievement. This understanding is important because across all educational levels, from elementary school through university, teachers assess their student's academic achievement through their grades in their assigned courses. Thus, this understanding has important consequences both for research and classroom practice. Conceptually, the current theoretical framework for investigating the relationship between indicators of motivation and academic achievement may be represented using Figure 1-1.

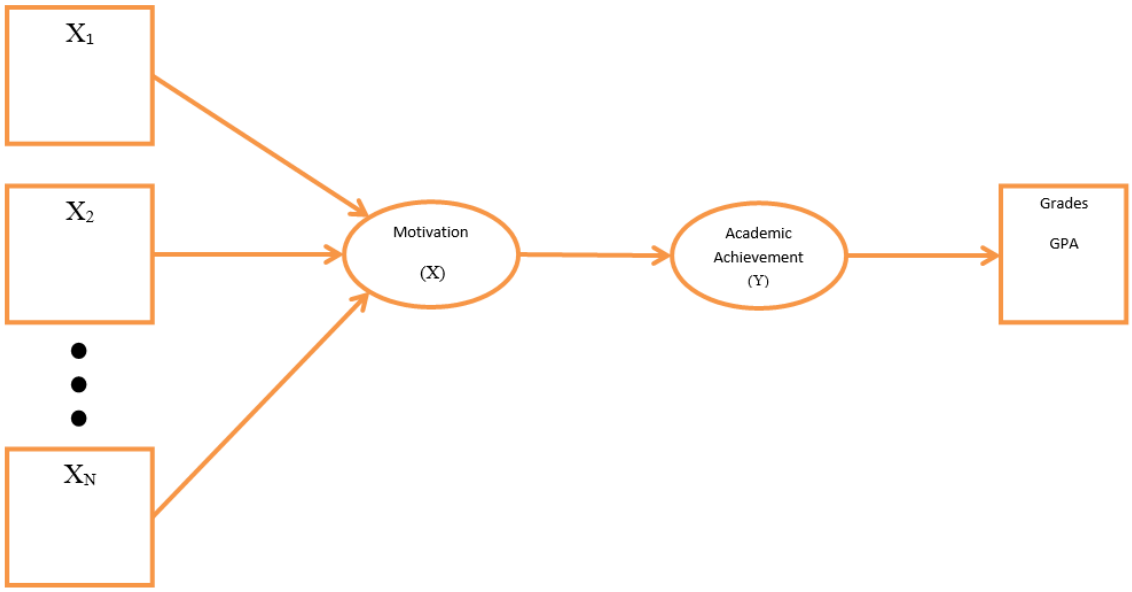

Figure 1-1. A conceptual diagram of current research framework

In Figure 1-1, X1, X2,.. XN are different indicators of motivation for academic achievement. The outcome variable (Grades) could be a student's final grade in an assigned course or overall GPA. We note that the framework described in Figure 1-1. implicitly assumes a proportional relationship between motivation and academic achievement. Also, because there is no distinction in the functional role(s) of the different indicators of motivation in current motivation questionnaires, this framework assumes, albeit implicitly, that all the indicators in a motivation questionnaire play the same role namely, that each is a predictor of different aspects of a student's motivation for academic achievement (Pintrich & de Groot, 1990; Bryan, Glynn, & Kittleson, 2011; Kim, et al., 2012). However, a scrutiny of the indicators in motivation questionnaires suggests that they might have different properties. Through this difference in their properties, one expects that some of the indicators might play different role(s) with respect to a student's academic achievement. I hypothesize that this lack of distinction in the role(s) of each indicator in a motivation questionnaire may be responsible for some of the challenges of the current theoretical model for investigating the relationship between motivation and academic achievement using the different motivation questionnaires. The following are some results from the research literature:

There are differences in epistemological beliefs amongst students about mathematical knowledge and how it is acquired and these differences correlate with differences in their self-regulated learning. Other studies report that a choice of learning strategy amongst students is not fixed but may be driven by the prevailing motives for learning at the time. Thus, a student may alternate between extrinsically motivated or intrinsically motivated learning from one activity to the next. Also, students might change both their epistemological beliefs and learning strategies as they progress through school and these changes might have a direct or indirect effect on their academic achievement (Buerk, 1982; Schommer, Crouse & Rhodes, 1992; Cano, 2005). The current theoretical framework for investigating the relationship between motivation and academic achievement may not offer a plausible account of these observed differences.

There are gender differences in expectations for success and attributions to failures. While male students tend to claim ability as a reason for success, female students tend to claim effort. Also, female students tend to discount their academic ability even when they have good reasons based on their academic performance to do otherwise (Fennema, 1989; McLeod, 1992). The current theoretical framework for investigating the relationship between indicators of motivation and academic achievement may not offer a plausible account of these observed differences.

There are differences amongst students in their self-efficacy beliefs, motivation, and academic achievement across the various school subjects. “The correlations are not so high that the same levels of motivation and engagement predominate across school subjects for any given student” (Liem & Martin, 2012, p. 7). The current theoretical framework for investigating the relationship between indicators of motivation and academic achievement may not offer a plausible account of these observed differences.

With the current theoretical framework, it is difficult to envisage a research design that would offer a plausible account of the above findings in the research literature. This difficulty is a feature of this framework because it arises through a lack of differentiation in the role(s) of the different indicators in a motivation questionnaire. Also, the apparent lack of agreement on how to constitute the motivation questionnaire undermines our ability to

compare results and assess the importance of research findings. This impedes research progress because it limits our ability to synthesize work.

To advance our understanding of the relationship between motivation and academic achievement, a theoretical framework for investigating this relationship should reflect as much of our realities as possible. Such a framework should offer a plausible account of our lived experience as everyday observers of our students. These include differences in their academic ability, expectancy, motivation, a gender effect if one exists, etc. With the current theoretical framework, any of the differences cited above may likely be interpreted as due to differences in a student's motivation for academic achievement. For example, a gender effect has been blamed for the low enrolment of women in science, technology, engineering and mathematics (STEM) programs compared to their representation in the population. With the current theoretical framework, this difference might be interpreted as differences in motivation between male and female students. The current framework is not configured to offer a plausible account of this and other effects.

1.2. A categorization of academic achievement variables

A core theme of this thesis is that motivation is a personal affair and should be understood from an individual perspective. Through differences in want and needs amongst our students, we can account for why different students might show different levels of motivation for the same activity. We should expect a theoretical framework for investigating the relationship between indicators of motivation, motivation and academic achievement to allow a plausible account of why different students may choose to engage in different activities (motives), the impact of differences in how different students might engage the same learning activity (e.g., intrinsic or extrinsic motivation) and possibly, resulting in differences in their outcomes; the impact of differences in their academic abilities, academic preparation and possibly, gender differences. This dissertation claims that such a theoretical framework should include two categories of variables namely: intention variables and action variables (Bandura, 2001).

The intention variables address the question of *whether* and thus, the *likelihood* that different people might engage in different activities (Bandura, 2001; Jose, 2013). The

action variables are also known as process or activity variables. These variables may take two forms: mediator and moderator variables. Mediator variables address the question of how different students might engage the same academic activity and its impact on their academic achievement. The moderator variables address the question of how *differences* in what each student brings to a learning activity might account for differences in their academic achievement. Below is a brief description of these variables and their possible role(s) in a student's academic achievement.

1.2.1. Academic motivator variables.

Motivator variables are those indicators of motivation that may compel one to pursue a goal; persuade one to take the necessary steps to achieve a desired outcome. These indicators have an inherent tendency to induce action. Also, there are about one's reasons for engaging in an activity or pursuing a goal. The inherent capacity of these indicators to induce an outcome may be seen as the *motivating property* of motivator variables (Lazarus, 1991). With respect to academic achievement, examples of motivator variables are pride (e.g., anticipatory pride of future academic achievement), academic interest, academic achievement goals, the importance of mathematics to the future career goals of a student, etc. Academic motivator variables embody one's motives; one's intentions; one's reasons for engaging in an academic activity or for pursuing an academic goal (Fowler & Fowler, 1995)

1.2.2. Academic mediator variables

How students learn might depend on their reasons for learning and also, on how they intend to use the acquired knowledge. The research literature identifies different methods of learning, e.g., intrinsically and extrinsically motivated learning. The different methods of learning serve different purposes and one expects that they might yield different academic outcomes. From our experience as teachers and educators, we know that different students come to each learning activity from different places, with different needs, different career and academic achievement goals. What may be important to one

student may be of little consequence to another student. We must assume that students are aware of the different methods of learning and also, their pros and cons. We should expect that each student, mindful of her learning needs, career and achievement goals, would choose a method of learning that maximizes her objectives. It is for this reason that a difference in achievement outcomes with the different methods of learning, by itself, is not an indication that one is inherently better than the other. The differences in outcomes should be expected (Lazarus, 1991; Nolen, 1996). To account for how different students might engage the same learning activity, a theoretical framework for investigating the relationship between motivation and academic achievement should include academic mediator variables.

1.2.3. Academic moderator variables

Academic moderator variables may account for differences in academic achievement through differences in what each student brings to a learning activity. From our experience as teachers and educators, we know that different students come to each academic activity with different abilities. For example, differences in mathematics self-efficacy belief, differences in academic ability, and differences in socio-economic background. Also, there may a gender effect, differences in academic preparations amongst the students, etc. To account for these differences, a theoretical framework for investigating the relationship between motivation and academic achievement should include academic moderator variables.

In this chapter, I described three categories of academic achievement variables namely, motivators, mediators and moderators. This classification is both necessary and required because at its most basic level, all forms of human activities may be conceived as transactional processes. Each, a description of how one engages her environment and we have no reason to assume that learning; all forms of learning might be different from other forms of human activity (Lazarus, 1991). In subsequent chapters, I will argue that to understand and describe the impact of motivation on academic achievement, requires that we account for why students go to school in the first place (motivators for learning), the impact of how different students might engage the same learning activity (academic

mediator variables) and also, the impact of how differences in their academic abilities (academic moderator variables) might affect their outcomes.

Chapter 2.

A classification of academic achievement variables

2.1. Introduction

In Chapter 1, I identified three categories of variables that I claim are required for investigating the relationship between motivation and academic achievement: motivators, mediators and moderators. In this chapter, I will address the question of how to constitute a motivation questionnaire for investigating the relationship between motivation and academic achievement. Then, I will classify each of the eleven indicators of motivation identified in this dissertation into one of these three categories. With the three categories of variables, I will propose a theoretical framework for investigating the relationship between motivation and academic achievement. I will end this chapter with my research objectives.

2.1.1. How should we constitute the motivation questionnaire?

> Intentions and actions are different aspects of a functional relation separated in time (Bandura, 2001, p. 6)

At the heart of social cognitive theory is the idea of personal agency characterized by intentionality, forethought and premeditation (Bandura, 1997, 2001). Through personal agency, people take responsibility for their lives, set goals and make decisions about how best to realize those goals. However, for one to realize her intentions, she must also take appropriate action(s). The intention variables, as the name suggests, are about one's intents, one's motives. They concern one's reason(s) for engaging in an activity or pursuing a goal. The intention variables are those variables that may initiate and sustain one's goal pursuit. Because they initiate and sustain goal pursuit, the intention variables are stable; they are persistent and they are directly related to a goal. A significant change in any or some of one's intention variables with respect to a goal might affect goal commitment and subsequently, the likelihood that she may realize that goal. With respect to academic achievement, this dissertation claims that a student's intention variables

embody her collective thoughts and motives towards an academic goal. That it is through differences in intention variables amongst students; through differences in their motives, that we may answer questions about why different students might enrol in different programs, or offer plausible accounts of why different students might show different attitudes to different academic activities (Lazarus, 1991). Amongst the eleven indicators of motivation identified in this dissertation, the intention variables are hope, pride, academic interest, academic achievement goals, perceived usefulness of learning mathematics and the importance of mathematics to the future career goals of each student.

The action variables of academic achievement are those variables that might be called upon during an academic activity to help realize a goal. Action variables are also called process or activity variables. Through a time separation between the intention (motivation) variables and action variables, action variables are future events with respect to a desired goal. Also, through this time separation, action variables differ from motivation variables by being transient and less persistent than motivation variables. Action variables are instantiated during an activity and their instantiations then disappear. It is for this reason that for a given student, her action variables might take different values (e.g., intrinsic or extrinsic motivation) for different activities. The difference in values for the action variables might be due to changes in a student's epistemological belief or learning strategy as she progresses through school, or move from one course to the other. It may also be due to changes in her academic interest, career goals, or control over tasks that determine achievement outcome. (Bandura, 2001; Cano, 2005). With respect to the eleven indicators of motivation identified in this dissertation, the action variables are intrinsic motivation, extrinsic motivation, mathematics self-efficacy belief, self-determination, and anxiety about mathematics assessment.

I return to the question of how to constitute a motivation questionnaire and ask the following questions:

> What is motivation? Given an arbitrary set of variables say A, B, C, .Z, *how* and *why* should we determine if any of them, some of them, all of them, or none of them is a motivating variable? What are the necessary and sufficient conditions for a variable to be deemed a motivating variable?

This dissertation sees no theoretical reason why each of us given the above task, may not choose the same set of variables from the given set. The question then is how do we all get to the same set of variables?

Fowler and Fowler (1995, p. 887) defined motivation through motive as follows:

> Motive, as a noun is defined as something that *induces* a person to act in a certain way; as an adjective, as something that has the *tendency* to make one *to initiate action*; as a transitive verb (motivate), as something that supplies *a motive, a reason for one's behavior*. (italics mine)

Bryan, et al. (2011, p. 1050), defined motivation as "an internal state that *arouses, directs, and sustains goal-oriented behavior".* (italics mine)

On emotions and behavior, Lazarus (1991, p. 94) wrote:

> There would be no emotion if people did not arrive on the scene of an encounter with a *desire*, *want, wish, need, or goal commitment* that could be advanced or thwarted. The *stronger or more important the goal, the more intense is the emotion*, other things being equal. (italics mine)

The various statements and definitions about motives and motivation referenced above all suggest a variable that, by itself and acting alone, has the capacity to persuade one to do something about something; a variable with an inherent capacity to persuade one to *initiate action or act in a particular way* (Fowler & Fowler, 1995; Bryan, et al., 2011). It also suggests that a person with *more* of this variable, all other things being equal, is *more motivated* than a person with less of it (Lazarus, 1991, p. 94). With Lazarus (1991), Fowler and Fowler (1995), Bryan, et al. (2011), this dissertation proposes the following two conditions as necessary and sufficient conditions for a variable to be deemed a motivating variable:

1. It must have an ordinal property. This property is required because it allows a less than or greater than comparisons.

2. It must have the capacity by itself, to induce an outcome; to allow one to infer the likelihood that one might initiate action about something, or act in a given way about something. This property is required because *it is the motivating property* of motivation variables.

With these two properties, I claim that amongst the eleven indicators of motivation identified in this dissertation, the motivation variables are: student's academic interest, student's academic achievement goals (e.g., mastery of an activity or successfully completing a task), hope, pride, personal relevance of learning mathematics, and the importance of mathematics to the future career goals of each student. Each of these indicators satisfies the necessary and sufficient conditions for motivating variables as stated above.

I now turn to the action variables of academic achievement identified in this study namely: intrinsic motivation, extrinsic motivation, self-determination, self-efficacy belief, and anxiety about mathematics assessment. In the research literature each of these indicators is frequently cited as an indicator of motivation (Glynn, Taasoobshirazi & Brickman, 2009; Kim et al., 2012). Before we address the question of whether intrinsic and extrinsic motivation are motivating variables, it is necessary that we ask and answer the following questions:

> *How* and *when* does a student enrolled in a program of study, e.g., a Bachelors program in Mathematics, decide how to engage the activities that determine achievement outcomes?

This could be done generically, for all assigned courses required for the program of study; or done adaptively, on a course-by-course basis. Done generically would describe a situation where one makes a determination on how to engage all required courses in a program of study without regards to the nature of the activity, its value and significance, how performance would be measured and also, one's control over tasks that determine achievement outcomes. Done adaptively means that each decision is made on a course-by-course basis, taking into consideration, the nature of the activity, how outcome will be determined, its value and significance with respect to the student's academic achievement goals, career objectives and also, one's control over activities that determine achievement outcomes.

The control value theory of achievement emotions (Pekrun, Elliot & Maier, 2006; Pekrun, Frenzel, Goetz, & Perry, 2007; Pekrun & Stephens, 2009) makes two appraisals with respect to applying that theory to students' academic achievement. The first appraisal is that of value and significance. This is a *me* appraisal; because it is about one's values,

interests, desires, one's wants and needs, goals, etc. The second appraisal is that of *control.* This is about one's control over activities that determine achievement outcomes. This is also about one's academic ability, and mathematics self-efficacy belief. This dissertation argues that there is also a third appraisal, albeit not part of the control value theory but an important appraisal. This third appraisal is about *how* the required knowledge would be acquired. This third appraisal takes into account the nature of the outcome (e.g. multiple choice examination vs. a written test). This appraisal is both important and required because we may not separate how one acquires knowledge from how she intends to use the knowledge; from the purpose and reason(s) for seeking the knowledge. This dissertation claims that it is with these three appraisals that a student decides how to engage a learning activity. Because different students might have different academic interests, different career needs, different achievement goals, and different academic abilities, we should expect that each student mindful of her needs may choose a form of learning engagement that best serves those needs (Lazarus, 1991; Nolen, 1996). We may describe this decision making process using the path diagram below:

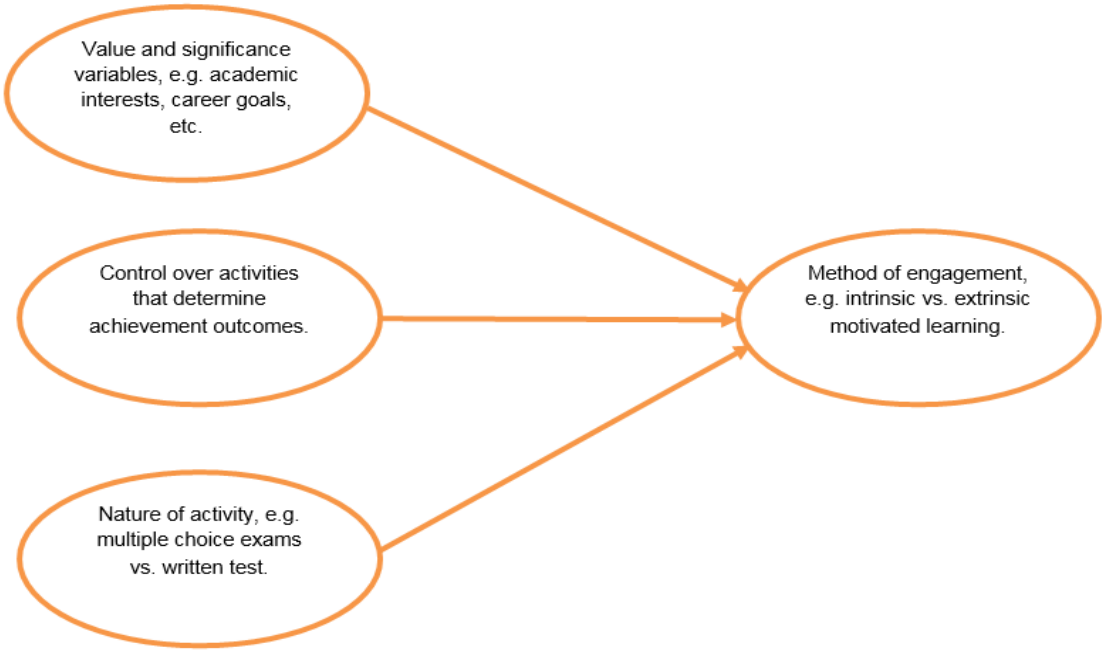

Figure 2-1. A conceptual view of how one might decide to engage an activity

Also, the various definitions of intrinsic and extrinsic motivation in books and the research literature acknowledge and even stipulates to the above claim; that one's choice of how to engage a learning activity is not fixed but driven by one's reasons for learning.

For example, Schunk, Pintrich and Meece (2008, p.236) defined intrinsic and extrinsic motivation as follows:

> Intrinsic motivation refers to motivation to engage in an activity for its own sake. People who are intrinsically motivated work on tasks because they find them enjoyable. Task participation is its own reward and does not depend on explicit rewards or other external constraints.
>
> Extrinsic motivation is motivation to engage in an activity as a means to an end. Individuals who are extrinsically motivated work on tasks because they believe that participation will result in desirable outcomes such as a reward, teacher praise, or avoidance of punishment

The two preceding statements on intrinsic and extrinsic motivation affirm that one's choice of learning strategy is not fixed; that a student may make different choices as she moves from one activity to the next. Also, these statements affirm that the value of an activity variable might change for each student from one activity to another. We also note that through their definitions, each of intrinsic and extrinsic motivation serve a different purpose; each could be used by different students or by the same student at different times, to achieve different academic or career goals. Thus, through their definitions, intrinsic and extrinsic motivation have nominal properties; they are *nominal variables*. A student may alternate between them for different activities but a student is not expected to exhibit both motivations simultaneously for the same activity. This constraint of having a nominal property implicit in their definition is a strong argument against any claim that each or both of them are motivating variables. Furthermore, it restrains us from collecting research data for the two variables (intrinsic and extrinsic motivation) for the same activity from a research participant. If we do, we might not know which of the two variables (intrinsic or extrinsic motivation) that a student used to engage the activity.

It is for the above reasons that this dissertation argues that a more appropriate representation of intrinsic and extrinsic motivation in a motivation questionnaire or in a theoretical model for investigating the relationship between motivation and academic achievement may be as a category of variables; as mediator variables of academic achievement. With this representation, a student may use one or the other to engage an activity, but not both. A student may also alternate between the two states from one activity to the next. This representation is in line with the definition of these variables. Having both present in a motivation questionnaire as independent variables may not be consistent with

their definition because it suggests that one could use both variables at the same time to engage the same academic activity.

With respect to the claim in the research literature that mathematics self-efficacy belief, self-determination, and anxiety about mathematics assessment are indicators of motivation (Glynn, et al., 2009). This dissertation argues as follows:

First, through a time separation between intention (motivation) and action (activity) (Bandura, 2001), mathematics self-efficacy belief, self-determination, and anxiety about mathematics assessment are activity variables. As activity variables, for each student these variables may take different values as a student moves from one activity to the other. Also, through their properties, mathematics self-efficacy belief, self-determination, and anxiety about mathematics assessment are potentials. They are academic potentials and they could be used to describe a student's control over tasks that determine achievement outcome. However, unlike intrinsic and extrinsic motivation, a student may apply all three academic potentials simultaneously for the same activity. Also, unlike intrinsic and extrinsic motivation where each student makes a conscious and a deliberate decision on *how to engage an academic* activity (intrinsic or extrinsic motivation), mathematics self-efficacy belief, self-determination and anxiety about mathematics assessment as academic potentials, may describe a student's *inherent capacity rather than a choice.* For these reasons, mathematics self-efficacy belief, self-determination and anxiety about mathematics assessment constitute a different category of indicators than intrinsic and extrinsic motivation.

As academic potentials, differences in the levels of each of these potentials might represent important differences in a student's control over activities that determine achievement outcomes and thus, to differences in her academic achievement. This dissertation claims that mathematics self-efficacy belief, self-determination and anxiety about mathematics assessment are moderator variables of academic achievement. With the properties of indicators identified in this dissertation, I classify the eleven indicators of motivation identified in this dissertation as either a motivation variable, a mediator variable or a moderator variable. This classification is shown in the table below:

Table 2-1. A classification of variables in a motivation questionnaire

Variable	Ordinal property	Motivating property
Hope	Yes	Yes; variable may initiate goal directed behavior; motivation variable
Pride	Yes	Yes; variable may initiate goal directed behavior; motivation variable
Student's academic interest	Yes	Yes; variable may initiate goal directed behavior; motivation variable
Student's academic achievement goal	Yes	Yes; variable may initiate goal directed behavior; motivation variable
Personal usefulness of learning mathematics	Yes	Yes; variable may initiate goal directed behavior; motivation variable
Importance of mathematics to career goals	Yes	Yes; variable may initiate goal directed behavior; motivation variable
Intrinsic motivation	No; by definition	No; a nominal variable; an activity variable, mediator variable
Extrinsic motivation	No; by definition	No; a nominal variable; an activity variable, mediator variable
Self-efficacy belief	Yes	No; ordinal variable; an activity variable, moderator variable
Self-determination	Yes	No; ordinal variable; an activity variable, moderator variable
Anxiety about mathematics	Yes	No; ordinal variable; an activity variable, moderator variable

With this classification, amongst the eleven indicators identified in this dissertation the indicators of motivation (motivation variables) are: hope, pride, student's academic interest, student's academic achievement goal, personal usefulness of learning mathematics, and the importance of mathematics to the future career goals of each student. The mediator variables are intrinsic and extrinsic motivation, and the moderator variables are mathematics self-efficacy belief, self-determination, and anxiety about mathematics assessment.

The choice of these eleven variables for this theoretical study was dictated by convenience and thus, purely accidental. The primary goal of this dissertation (study 1) was to determine the indicators of motivation that accounts for the most variance in a student's mathematics achievement and, the amount of this variance. The eleven

indicators classified above are the indicators frequently cited in the literature as indicators of motivation for mathematics achievement (Glynn & Koballa, 2006; Harackiewicz, et al., 2008; Pekrun, et al., 2011) as identified in this dissertation (see section 1.1., p. 4) of this thesis. This dissertation makes no claim that this is an exhaustive list of motivating variables for academic achievement or, of academic mediator variables or, of academic moderator variables. What this dissertation claims is that with the conditions for motivating variables identified in this dissertation, one may determine whether a given variable is a motivating variable or not.

2.2. A new framework for academic motivation questionnaire

A theoretical framework for investigating the relationship between motivation and academic achievement should be judged by what it can account for; by whether it allows plausible accounts of our everyday lived experiences of our students, about how and why they learn. For example, we could use such a framework to investigate the impact of mathematics anxiety on student's academic achievement, and the impact of different motivation strategies, teaching strategies, academic preparations on student's academic achievement. This dissertation argues that such a framework should include and identify motivator, mediator and moderator variables.

Academic motivator variables embody a student's collective intentions towards a goal. Through differences in motives for different students with respect to a goal, we may account for observed differences in their motivation for different activities. The mediator variables are required to give plausible accounts of impact of differences in how different people might engage the same academic activity (intrinsic or extrinsic motivation). We could also extend these variables to include different motivation strategies, including teaching strategies, technology in the classrooms, etc. The moderator variables are required to give plausible accounts of differences in capacity amongst students, differences in socio-economic backgrounds, academic preparations and also, gender differences. An academic moderator variable could be any variable that we hypothesize as impacting the relationship between motivation and academic achievement.

Through our lived experience as teachers and educators, we can attest that the different categories of variables mentioned above do impact student's academic achievement. It is therefore important that a theoretical framework for investigating the relationship between motivation and academic achievement should include these categories of variables. With these categories of variables, I propose a moderated-mediation model (Hayes, 2013) as the appropriate theoretical framework for investigating the relationship between motivation and academic achievement. A conceptual diagram of this framework is shown below:

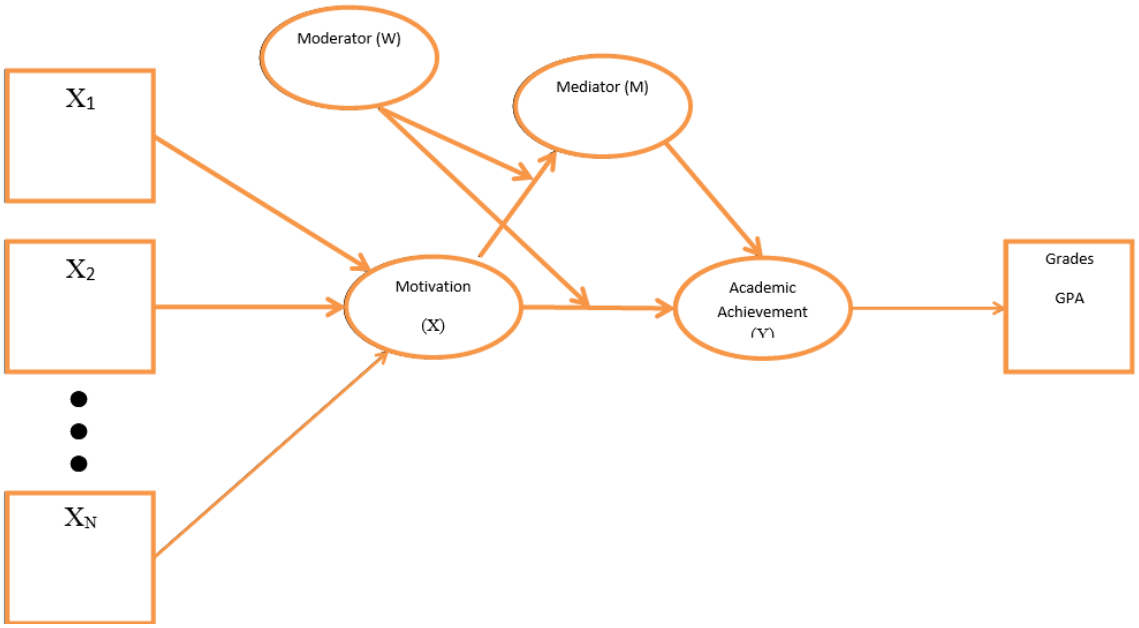

Figure 2-2. A conceptual diagram of proposed framework (Hayes, 2013)

The above framework is also called a conditional process model (Hayes, 2013). This is because it could be used to investigate the conditional direct and indirect effects of exogenous variable(s) on an outcome variable. This framework has a broad reach with respect to its application to theoretical studies in mathematics education. This is because both the mediator and moderator variables could be combined serially or in parallel. The number in each chain is only limited by theory.

2.3. Research objectives

This dissertation has the following research objectives

2.3.1. Study 1: Investigation of the variables that impact mathematics achievement

In this dissertation, I will use multiple regression procedures to determine which combination of the eleven indicators of motivation identified in this dissertation account for the most variance in student's mathematics achievement, the proportion of this variance, and the specific contribution of each indicator to mathematics achievement.

2.3.2. Study 2: A mediation and moderated mediation process analysis

The theoretical framework proposed by this dissertation addressed three primary research questions namely: why a person may show different levels of persistence for different activities (motivation); why different ways of engaging an activity may lead to different outcomes (mediation) and why differences in what different people bring to a learning activity may lead to different academic outcome (moderation). While the Baron and Kenny's mediation model (1986) has wide applications in many areas of social science research, it has limited or no application to research in education. This is because with motivation (X) as an exogenous variable and academic achievement (Y) as an endogenous variable, the goal of mediation might be to reduce the strength of the regression weight of motivation (X) on academic achievement (Y). However, a major challenge for researchers and educators is how to motivate our students. Thus, for theoretical studies in education, the reverse process is needed namely, how to increase the strength of the regression weight of motivation (X) on academic achievement (Y).

The research literature appears to be silent on which of the eleven indicators of motivation identified in this dissertation mediate and/or moderate academic achievement (Pintrich & de Groot, 1990; Glynn & Koballa, 2006; Bryan, et al., 2011; Kim, et al., 2012). In this dissertation, I have argued that intrinsic and extrinsic motivation are academic mediator variables. I also argued that mathematics self-efficacy belief, self-determination, and anxiety about mathematics assessment are moderator variables. Here, I will implement the theoretical framework proposed by this dissertation by exploring the effect of intrinsic motivation, extrinsic motivation as mediators of the relationship between motivation and mathematics achievement. I will also explore the conditional direct and indirect effects of motivation on mathematics achievement using mathematics self-efficacy belief as the moderating variable, and intrinsic motivation or extrinsic motivation as a mediating variable. The rational for these investigations was that each suggests a new approach to theoretical studies in education; a new way for investigating the impact of different indicators on the relationship between motivation and academic achievement.

2.3.3. Study 3: On persistence, self-efficacy belief and motivation

Self-efficacy belief is at the heart of social cognitive theory and the focus of many of the research on motivation and academic achievement. In this part of my dissertation, I will use multiple regression procedures to determine which combination of the indicators of motivation identified in this dissertation, accounts for most of the variation in a student's mathematics self-efficacy belief, and the proportion of this variance. I will also use a discriminant analysis procedure to investigate which combination of the indicators of motivation identified in this dissertation could be used to discriminate amongst students with low and high mathematics self-efficacy beliefs. My expectation is that combining the results from both studies might offer helpful insights on the indicators that accounts for differences in persistence that we often associate with students with different mathematics self-efficacy beliefs.

Chapter 3.

Research Methodology

3.1. Introduction

This chapter is organized as follows: First, we will meet the research participants and then, I will describe the research instruments. This will be followed by my research procedures. This includes data collection procedures and how I will analyze the data collected for this study. The choice of how to analyze the data will focus on my research objectives as stated in Chapter 2. The expectation is that through these data analysis procedures this dissertation might shed some light on important questions about the nature of the relationship between indicators of motivation, motivation and achievement in post-secondary mathematics.

3.2. Research Participants

The research participants were students attending a public university in Sri Lanka. Sri Lanka like Canada, Australia, etc. is a commonwealth country. While local languages are spoken at home and outside official circles, English is the official language and also, the language of instruction in schools, colleges and universities. Thus, the research instruments for this dissertation were used as written in English; no translation was necessary.

The students were registered in a first year mathematics course (AM 1003 – Matrices) and a second year mathematics course (AM 2002 – Numerical Analysis). Each of these two classes had some students who were repeating the course, perhaps having taken and failed the course in previous years. We were unable to distinguish the repeaters through their registration numbers and also, for privacy issues, made no effort to do so. Students' participation in this research was solicited through an announcement made in each of the two classes on my behalf by a colleague. The announcement advised the students about the nature of the research and why their participation was important.

Students' participation was voluntary and consistent with the provisions of the SFU Research Ethics board.

Out of a total of about 475 students in both classes, initially 103 students fully completed the research questionnaire. This number was just at the edge of the sample size requirement for this dissertation. At my request, my colleague went back to each class and appealed to those students who had not completed the questionnaire to do so. This time, we promised a gift certificate of 500 Rupees (Sri Lanka) to any student who successfully completed the survey. At the insistence of the SFU Research Ethics board, we also promised a gift certificate of 100 Rupees to any student for her participation in the survey irrespective of whether she successfully completed the survey or not. The SFU Research Ethics Office had insisted that any student who participates in the survey must receive an honorarium given that those who successfully completed the survey received an honorarium.

From this second attempt, 18 additional students completed the research questionnaire bringing the total number of research participants to 121 students. The distribution of the research participants were 67 students from the AM 1003 Matrices class and 54 students from the AM 2002 Numerical Analysis class. Of the AM 1003 Matrices class, there were 39 males and 28 females. The AM 2002 Numerical Analysis class, consisted of 23 males and 31 females. For each class, the students were from six different departments in the faculty of science of the university.

3.3. Research Instruments

The research instruments for this dissertation are the science motivation questionnaire (Glynn, et al., 2006; 2009; 2011), academic achievement emotions questionnaire (Pekrun, et al., 2011), academic interests and academic achievement goals questionnaires (Harackiewicz, et al., 2008), and a single item question on the importance of mathematics to the future career goals of each student.

The science motivation questionnaire is a six variable self-report instrument that assesses the motivation of high school and university students to learn science. The

variables in this instrument are intrinsic motivation, extrinsic motivation, self-determination, self-efficacy belief, personal relevance of learning science and anxiety about science assessment. There were five questions for each of the six variables totalling 30 questions for this instrument. Each item was answered on a 7-point Likert scale from (1 = strongly disagree) to (7 = strongly agree). Responses on anxiety about mathematics assessment were reflected using the equation ((maximum score +1) – student's response)) to be in alignment with their other responses. With this instrument, a student's motivation to learn science is determined through her cumulative score on the thirty questions that composed this instrument. This 30-item instrument is reported to have a Cronbach alpha = 0.93 and the results are reported to be strongly correlated with student's performance in high school and university science courses. (Glynn, & Koballa, 2006; Glynn, et al. 2009).

The academic achievement emotions questionnaire is a 24-item instrument. Pekrun et al. (2011) report a Cronbach alpha that varies from 0.75 to 0.85 for the total instrument. This dissertation used six questions from this instrument without any change, three questions for hope and three questions for pride. Each item was answered on a 7-point Likert scale from (1 – strongly disagree) to (7 – strongly agree). The data for students' academic achievement goals and academic interests in mathematics were collected using the students' academic interest and academic achievement goals questionnaires (Harackiewicz, et al. 2008). Responses are provided on a 7-point Likert scale from (1 = strongly disagree) to (7 = strongly agree). These instruments were adapted for this study by changing the word "psychology" to "mathematics." A Cronbach alpha of 0.90 was reported for academic interest and 0.87 for academic achievement goals (Harackiewicz, et al. 2008).

The final research question was a single item on the importance of mathematics to the future career goals of each student. This question was also scored on a 7-point Likert scale from (1 = strongly disagree) to (7 = strongly agree). Altogether, the research questionnaire used in this study consisted of 51 questions. Again, the choice of indicators for this dissertation was dictated by my primary research goal (study 1). Through my primary research goal, the eleven indicators of motivation for mathematics achievement most referenced in the literature are six indicators from the science motivation

questionnaire (Glynn & Koballa, 2006; Glynn, et al. 2009).) each, with five questions for a total of 30 questions. Two from the academic achievement emotions questionnaire namely hope, pride (Pekrun, et al., 2011) and each measured with three questions for a total of 6 questions. Two from academic interest and academic achievement goals questionnaire (Harackiewicz, et al., 2008) and each measured with 7 questions for a total of 14 questions. With a single question on the importance of mathematics to the future career goals of each student, the questions used for this dissertation sums up to 30 + 6 + 14 + 1 = 51 (Appendix B). The outcome variable was a student's mathematics achievement determined through her performance (grades scored from zero to 100) in the assigned mathematics courses (AM 1003 Matrices or AM 2002 Numerical Analysis) respectively. The results were provided by the course Instructors at the end of the semester.

3.4. Procedures and methods

Each student submitted responses online using a web link that was e-mailed to each student. Before completing the research questionnaire, each student was required to read and accept the terms and conditions stipulated on an informed consent document approved the SFU Research Ethics Board (Appendix A). The next page of the survey collects information on student's registration number, gender, and field of study. Student's registration number was required, as it would be used to locate a student's grade in her assigned mathematics course. In subsequent pages, each student was required to respond to fifty-one research questions. The questions were presented in randomized order across the survey pages. The survey design required that each student answer all the questions in the order presented on the survey. Also, a student was required to commit all responses on a given page before advancing to the next page. Furthermore, once a student committed her responses, they could not be changed nor was a student allowed to go back to previous pages. However a student may choose to quit the survey at any time by selecting a "Discard responses and quit" button present on all pages of the survey. If a student selected this button, all responses including those previously committed would be discarded. The expectation was that this would eliminate the possibility of having missing values in the final data. However, it appeared that many students quit the survey either by closing the browser window or simply by exiting the system without selecting the

"Discard responses and quit" button as instructed. As a result, there were many incomplete entries and missing values. All such incomplete responses were discarded and are not part of the sample data.

The completed student's responses consisted of student's registration numbers; gender, major/field of study, and their answers to the fifty-one research questions. These were exported as fields to a Microsoft Excel file. Each row on this file was one observation, a case associated to a student through the student's registration number. The student's registration numbers were subsequently used to request their final grade from their mathematics course instructor. Although the assigned mathematics courses for this study were a first year (AM 1003) and second year (AM 2002) mathematics courses, each class was composed of first, second and third year university students. Some of the students might be repeating the course having failed it previously. The mean score and standard deviation for the first year and second year courses were M=60.29 and s=12.52, and M=60.31 and s=19.19, respectively. These values were used to standardize the final grade (Z score) for all the research participants and thus to combine the results from the two classes. Following the entry and standardization of student's final grade in their assigned mathematics courses, the column showing student's registration numbers in the research data was deleted as part of the SFU Research Ethics requirement to protect their privacy. The final research data consisted of rows of data showing each student's responses to the 51 research questions, her grade in the assigned mathematics course, and also her standardized grade.

3.5. Sample size requirements

The sample size for this dissertation was 121 observations (N = 121). Using the ten times rule (Hair, Hult, Ringle & Sarstedt, 2014), this sample size meets the sample size requirements for all the analysis proposed for this dissertation.

3.6. Reliability statistics for this dissertation

To determine the internal consistency and reliability of the items summed to obtain the scores for each of the indicators of motivation, Cronbach alpha was computed. The Cronbach alpha for the three items of the hope and pride scales were 0.63 and 0.72, respectively. When the two scales were combined to obtain a six-item academic achievement emotions scale, the Cronbach alpha was computed to be 0.78

Also, the Cronbach's alpha for each of the six scales of the science motivation questionnaire namely: extrinsic motivation, intrinsic motivation, anxiety about mathematics assessment, personal relevance of learning mathematics, mathematics self-efficacy belief and self-determination were 0.59, 0.79, 0.67, 0.61, 0.79, and 0.38, respectively. These results show a low value for the self-determination scale. The Cronbach alpha for the thirty-item scale that comprises the mathematics motivation questionnaire was computed to be 0.82. Its item-total statistics table showed that the Cronbach alpha ranged from 0.80 to 0.82 for any item deletion.

The Cronbach's alpha for the seven questions about students' academic interest was 0.74 while that for students' academic achievement goal was 0.76. The Cronbach alpha for the combined 14-item scale was determined to be 0.83. Its item-total statistics table if an item was deleted ranged from 0.80 to 0.83. Finally, I combined all the questions from all the scales to form a 51-item scale that comprises the indicators of motivation for achievement in mathematics. The Cronbach alpha for this scale was computed as 0.92. The item-total statistics table for this scale showed that the Cronbach alpha ranged from 0.91 to 0.92 for any item deletion. The stability of this instrument over any deletion of the scale questions indicates that this instrument had good internal consistency and reliability.

3.7. Research design

This dissertation was designed to investigate the relationship between indicators of motivation and achievement in post-secondary mathematics. My expectation was that some of these indicators might be strongly correlated with each other. For this reason, I explored the extent of their correlations by computing the variance inflation factors (VIF)

for each of the 11 indicators of motivation (a test for multicollinearity for all variables). The test for multicollinearity conducted for the eleven indicators showed that all VIF values ranged from 2.86 to 3.07. Since VIF = 3.0 is the threshold for multicollinearity, these results indicate that multicollinearity was not an issue for the indicators used in this dissertation.

3.7.1. Study 1 – A multiple regression analysis

With the eleven indicators identified in this dissertation as impacting mathematics achievement, this method was selected with the intent of resolving some of the controversies in the research literature with regards to the specific contribution of each of the indicators of motivation to mathematics achievement and also, to determine the set of indicators that accounts for the most variance in a student's mathematics achievement. The method of analysis would be a stepwise procedure (method=forward).

3.7.2. Study 2 – A mediation and moderated mediation analysis

In this part of my dissertation, I will implement the research framework that I proposed as the appropriate framework for investigating the relationship between indicators of motivation and mathematics achievement. My investigation will be in two parts. First, I will explore the effect of intrinsic and extrinsic motivation as mediating variables. My expectation is that the relationship between a student's motivation and her mathematics achievement might be impacted by how she learns mathematics (intrinsic or extrinsic motivation). Then, I will explore the effect of moderation. My premise is that, it is through moderation that we may account for the impact of gender, and other group effects like differences in socio-economic backgrounds of students, differences in mathematics self-efficacy belief amongst students, differences in mathematics anxiety amongst students, etc. For this study, I will conduct a moderated mediation analysis with mathematics self-efficacy belief as the moderating variable. In general, a partial least squares (PLS) or structural equation model (SEM) might be a better method for conducting the above analysis. However, for this study, I will use an SPSS macro called PROCESS (Hayes, 2013) for both the mediation and moderated mediation analysis.

3.7.3. Study 3 – Persistence, self-efficacy belief and motivation

Through social cognitive theory (Bandura, 1997, 2001), self-efficacy belief has become an important factor on the research on motivation and academic achievement. It has been argued that self-efficacy belief might account for the observed differences in persistence and thus, the observed differences in mathematics achievement amongst students (Pajares & Miller, 1994). In this dissertation, I have argued that self-efficacy belief is an academic potential; a static energy. I now argue that persistence is about emotions, it is about motivation and a kinetic energy variable. The more motivated one is, the more persistent she might be with regards to an activity. I claim that a static energy variable like self-efficacy belief is not likely to be the driver of a kinetic energy variable like persistence. In this part of my dissertation, I will explore the relationship between persistence, mathematics self-efficacy belief and motivation. I will use both multiple regression and discriminant analysis procedures. The first procedure would indicate the set of indicators that account for most of the variation in a student's mathematics self-efficacy belief. The second procedure would determine the set of indicators that discriminates amongst students with low and high mathematics self-efficacy beliefs.

Chapter 4.

Descriptive Statistics

4.1. Introduction

Eleven indicators of motivation were identified in this dissertation: mathematics self-efficacy belief, self-determination, anxiety about mathematics assessment, personal relevance of learning mathematics, intrinsic motivation, extrinsic motivation, students' academic achievement goals, student's academic interest, the importance of mathematics to future career goals, hope, and pride of academic achievement. Ten of these indicators were measured using a multiple-item scale while the importance of mathematics to future career goals was measured using a single question. Each scale question was based on a 7-point Likert typed scale. The distribution of students' responses for each of the 51 questions is summarized using a bar chart, with the item question as the title of each bar chart (Appendix C).

Each of the ten indicators was determined by summing students' responses on each of the items that composed its scale. Below are descriptive statistics and the correlation matrix for scales used in this dissertation.

4.2. Descriptive statistics of the explanatory variables and standardized grades (N = 121)

Table 4-1. Descriptive statistics table (N=121)

	N	Mean	SD	Median	Min	Max	Range	Skew	Kurtosis	SE
Hope	121	15.74	3.08	16.00	5.00	21.00	16.00	-0.93	1.02	0.28
Pride	121	15.40	3.44	16.00	4.00	21.00	17.00	-0.65	0.38	0.31
CareerG	121	5.84	0.98	6.00	3.00	7.00	4.00	-0.78	0.48	0.09
Interest	121	37.45	6.04	38.00	18.00	49.00	31.00	-0.52	-0.02	0.55
ExtMotive	121	28.64	3.91	29.00	13.00	35.00	22.00	-1.01	2.06	0.36
IntMotive	121	28.24	4.82	29.00	7.00	35.00	28.00	-1.10	2.05	0.44
Manxiety	121	16.98	5.33	17.00	7.00	31.00	24.00	0.40	-0.44	0.48
Usefullness	121	26.10	4.33	26.00	15.00	35.00	20.00	-0.27	-0.45	0.39
MSdeterm	121	25.06	3.63	25.00	15.00	33.00	18.00	-0.22	-0.35	0.33
MSbelief	121	24.94	5.03	26.00	8.00	35.00	27.00	-0.61	0.42	0.46
AchGoal	121	38.30	5.80	39.00	19.00	49.00	30.00	-0.83	0.82	0.53
StdGrades	121	59.95	27.50	65.58	0.01	96.51	96.50	-0.53	-0.98	2.50

All the scales with the exception of anxiety about mathematic assessment have a mild negative skew ranging from –1.10 to –0.22 indicating extreme values to the left of the distribution's center. For the anxiety about mathematics assessment scale, skew = 0.40 indicating extreme values to the right of the distribution's center. The kurtosis values for all scales ranged form a maximum value of 2.06 for extrinsic motivation to a minimum value of –0.02 for academic interest. With all skew and kurtosis values < 3, each distribution is not noteably differentiated from a normal distribution.

4.3. Correlation among academic achievement variables and with standardized grades (N = 121)

Table 4-2. Correlation statistics table (N=121)

	Hope	Pride	CareerG	Interest	ExtMotive	IntMotive	Manxiety	Usefullness	MSdeterm	MSbelief	AchGoal	StdGrades
Hope	1	.582	.446	.562	.239	.593	.295	.447	.385	.657	.586	.050
Pride	.582	1	.278	.305	.298	.350	.185	.273	.376	.590	.403	.146
CareerG	.446	.278	1	.628	.245	.574	.182	.454	.243	.480	.480	.003
Interest	.562	.305	.628	1	.260	.731	.368	.433	.448	.608	.556	.169
ExtMotive	.239	.298	.245	.260	1	.179	-.182	.281	.238	.328	.193	.032
IntMotive	.593	.350	.574	.731	.179	1	.353	.384	.298	.609	.562	.032
Manxiety	.295	.185	.182	.368	-.182	.353	1	.079	.094	.248	.146	.124
Usefullness	.447	.273	.454	.433	.281	.384	.079	1	.139	.296	.338	-.017
MSdeterm	.385	.376	.243	.448	.238	.298	.094	.139	1	.436	.352	.255
MSbelief	.657	.590	.480	.608	.328	.609	.248	.296	.436	1	.633	.185
AchGoal	.586	.403	.480	.556	.193	.562	.146	.338	.352	.633	1	.135
StdGrades	.050	.146	.003	.169	.032	.032	.124	-.017	.255	.185	.135	1

The correlations amongst the scales are as expected indicating for the most part that they reflect different aspects of the motivation. However, the correlations between scales and students' standardized mathematics grades are much lower than I expected. Their values ranged from almost zero (0.003) for the importance of mathematics to the future career goals of each student to a maximum value of 0.26 for self-determination. Personal relevance of learning mathematics was negatively correlated with mathematics achievement with value = -0.02.

Given the unexpected low correlations between the indicators of motivation with student's standardized grades, I split the sample (N = 121) into its two components, the first year and second year classes (AM 1003 Matrices class & AM 2002 Numerical Analysis class) with group sizes 67 and 54 respectively. My thinking was that with the mean and standard deviation for the first year and second year courses as (60.29, 12.52) and (60.31, 19.19) respectively, the large difference in their standard deviations might be a factor in the poor correlation of the standardized grades through standardization.

However, the descriptive statistics and correlation matrix for each class (AM 1003 Matrices and AM 2002 Numerical Analysis) was not substantively different from the combined result. For each class, all the indicators with the exception of anxiety about mathematics assessment have negative skew values. Also, the correlation statistics between the indicators and students' final grade for each class were not substantively different from the combined result. The result of this investigation confirmed that the poor correlation statistics between the indicators of motivation and students final grades for the combined class (N=121) was not due to standardization.

Chapter 5.

Data Analysis

5.1. Study 1 - A multiple regression approach

5.1.1. Introduction

The purpose of this analysis was an attempt to answer the following research questions:

> What proportion of the variance in a student's mathematics achievement could we explain using the eleven indicators of motivation? What indicators account for most of this variation?

These questions are usually addressed using standard multiple regression procedures where all the indicators are entered in one step. However, with eleven indicators of motivation identified in this dissertation, there is the issue of parsimony. An important research goal is to account for as much of the variation in a student's mathematics achievement as possible with the least number of the indicators of motivation. This motivated my decision to use a stepwise multiple regression procedure in which one indicator enters the analysis at each step. With this procedure, the statistical usefulness ($p \leq 0.05$) of each indicator entering or leaving the analysis at each step is indicated by how much the R^2 value for the regression model would be increased or decreased by its entry or exit from the model (Warner, 2013).

For this analysis, the dataset (N = 121) was the combined responses from the two classes (AM 1003 Matrices class and AM 2002 Numerical Analysis class), and the response variable was student's standardized grade. For this procedure, I tested my previous arguments that not all the eleven indicators identified in this dissertation are predictors of mathematics achievement.

5.2. Results

The regression model was statistically significant ($F_{1,119} = 8.31$, $p = 0.005$). With $R = 0.26$, $R^2 = 0.07$, and adjusted $R^2 = 0.06$, among all eleven indicators of motivation identified in this dissertation, only student's self-determination to learn mathematics met the selection criterion (Table 5.1).

Table 5-1. Coefficients table

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	11.513	16.979		.678	.499	-22.108	45.133
	MSdeterm	1.933	.671	.255	2.882	.005	.605	3.261

a. Dependent Variable: StdGrades

Because of this unexpected result, I examined the residual plots produced by this analysis (Appendix D). Both the scatter plots for the standardized residuals and the normal P-P plot of the standardized residuals show no discernible trend as would be expected given the low variance extracted. I comment on this unexpected result later.

5.3. Study 2 - Mediation, and moderated mediation analysis

5.3.1. Introduction

While multiple regression models may offer helpful insights about indicators that relate to students' mathematics achievement, these models are not easily adapted to investigating complex relationships between variables. A realistic theoretical model for investigating the relationship between the indicators of motivation and mathematics achievement, should offer plausible accounts of these effects. This dissertation proposed a moderated mediation model as a more appropriate model for investigating the relationship between motivation and mathematics achievement, specifically that intrinsic and extrinsic motivation are mediator variables, while mathematics self-efficacy belief,

self-determination, and anxiety about mathematics assessment are moderator variables. In this part of my dissertation, I investigate the effect of intrinsic motivation and extrinsic motivation as mediators of the relationship between motivation and mathematics achievement. Then, I will introduce mathematics self-efficacy belief as a moderator variable and conduct a moderated mediation analysis with motivation as the exogenous variable, mathematics achievement as the outcome variable and intrinsic and extrinsic motivation as separate mediators of this relationship.

5.4. Mediation analysis

In a simple mediation model, the total effect (c) is the sum of direct (c_1) and indirect effects (ab).We may describe a simple mediation model using the path diagrams shown below.

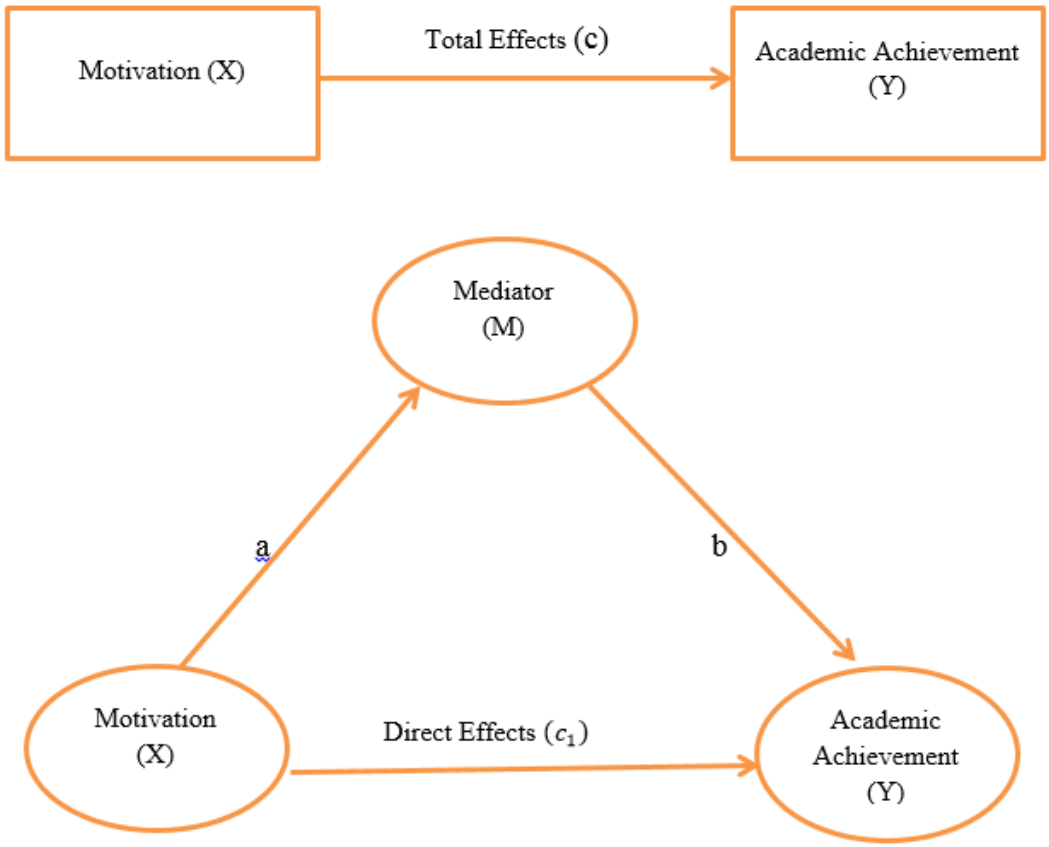

Figure 5-1. A simple mediation model

The idea of mediation is to find a mechanism that might reduce the strength of a total effect by reducing the correlation between an exogenous variable (X) and an outcome variable (Y). We could describe the direct and indirect effects of X on Y statistically, using two linear equations as shown below (Hayes, 2012, 2013).

$$M = a_M + aX + \in_M \qquad 1$$

$$Y = a_Y + c_1X + bM + \in_Y \qquad 2$$

Equation 1 describes the effect of X on M. Equation 2 describes the effect of both X and M on Y; $\epsilon_M \; and \; \epsilon_Y$ are error terms while $a_M \; and \; a_Y$ are constants. The indirect effect of X on Y is the product term ab where a is the coefficient of X in equation (1) and b is the coefficient of M in equation (2); the effect of M on Y controlling for X. The direct effect of X on Y is c_1 , the coefficient of X in equation (2). The direct effect is said to be significant if the coefficient c_1 is non-zero and its confidence interval excludes a zero value. Similarly, the indirect effect of X on Y is said to be significant if the product term ab is non-zero and its confidence interval excludes a zero value. The total effect of X on Y given by c , is estimated as the sum of the direct and indirect effects of X on Y and is shown below (Hayes, 2013; Warner, 2013)

$$c = \; c_1 \; + \; ab$$

From the above, the problem of a simple mediation analysis reduces to that of determining the proportion of the total effect that "passes through" a mediator variable (Hayes, 2013; Rose, 2013). Cases where the direct and indirect effects have different signs and the direct relationship *strengthened,* rather than weakened have been described as spurious and misleading mediations, and the mediating variable in this case, has been called a suppressor variable (Rose, 2013)

However, a mediation analysis where either intrinsic motivation or extrinsic motivation mediates the relationship between motivation and mathematics achievement and where the direct effect was less than the total effect would deny the claim in the research literature that each of these variables (intrinsic motivation or extrinsic motivation) facilitates academic achievement. This is because decomposition (a redistribution of effects) of the total effect into direct and indirect effects would suggest that while intrinsic and extrinsic motivation may be different ways of engaging an academic activity, neither actually facilitates academic achievement. The question posed by this investigation is thus as follows:

> If each of intrinsic motivation or extrinsic motivation relates positively to academic achievement, how would their contribution be manifested and how could we describe these effects theoretically?

This analysis will be in two parts. First, I will conduct two mediation analyses with three variables namely: motivation (X), mathematics achievement (students' grades in assigned mathematics course, Y) and intrinsic motivation or extrinsic motivation (M) in the role of a mediator. For the first mediation analysis, I will use intrinsic motivation as the mediating variable (M). I will repeat the analysis but substituting intrinsic motivation with extrinsic motivation as the mediating variable.

5.5. Moderated mediation analysis

For the second part of this study, I will conduct a moderated-mediation analysis. This requires four variables; three from the previous analysis – motivation (X) as the exogenous variable, mathematics achievement (Y) as the outcome variable and intrinsic motivation (M) as the mediating variable – plus a fourth variable, mathematics self-efficacy belief (W) in the role of a moderating variable. I will repeat this analysis by substituting intrinsic motivation for extrinsic motivation as the mediating variable (M). Statistically, we can describe this process using two linear equations with M and Y as the outcome variables as shown in equations 3 and 4 below (Hayes, 2012, 2013).

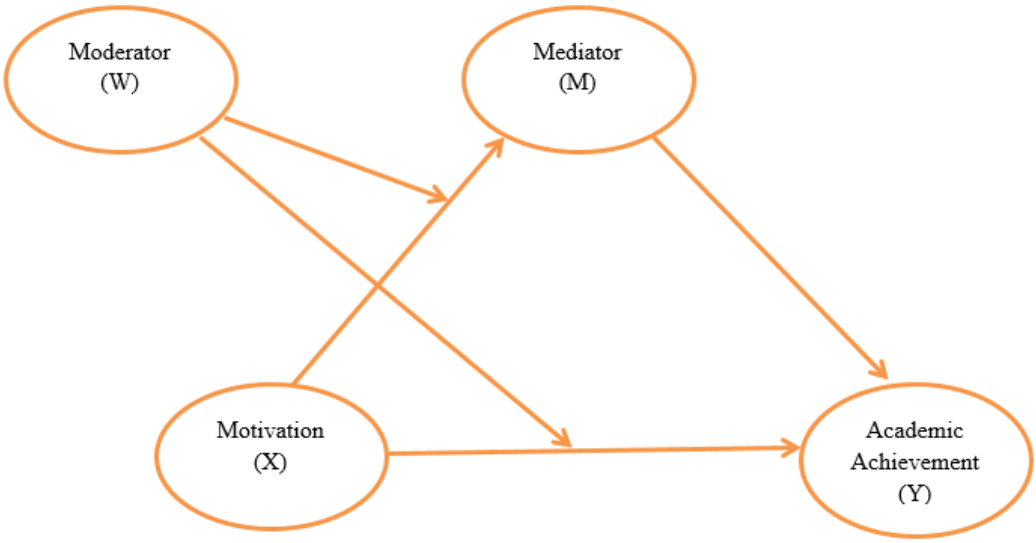

Figure 5-2. A path diagram for a moderated mediation analysis (Hayes, 2012)

Figure 5-2 is a path diagram for a moderated mediation model. Essentially we want to know if each of the coefficients of the interaction terms between W and X in equations (3) and (4) below is statistically different from zero.

$$M = a_M + a_1X + a_2W + a_3XW + \in_M \quad 3$$

$$Y = a_Y + c_1X + c_2W + c_3XW + b_1M + \in_Y \quad 4$$

The conditionality of the indirect effect of X on Y is determined by combining the terms involving X in equation 3 above to obtain:

$$M = a_M + (a_1 + a_3W)X + a_2W + \in_M$$

$$M = a_M + a_{11}X + a_2W + \in_M \quad 5$$

Where $a_{11} = (a_1 + a_3W)$ The indirect effect of X on Y is as before, the product $(a_{11}b_1)$ where a_{11} is the coefficient of X in equation (5), and b_1 the coefficient of M in equation (4). The conditionality of the indirect effect of X on Y is through a possible dependence of a_{11} on W (the moderating variable). Similarly, the conditionality of the direct effect of X on Y comes from combining the coefficients of X in equation (4) to obtain:

$$Y = a_Y + (c_1 + c_3W)X + c_2W + b_1M + \in_Y$$

$$Y = a_Y + c_{11}X + c_2W + b_1M + \in_Y \quad 6$$

Where $c_{11} = (c_1 + c_3W)$. It follows that the direct effect of X on Y is functionally dependent (conditioned) on the moderating variable W, if c_{11} depends W (Hayes, 2012, 2013).

For these analyses, the data are responses from first year students who took AM 1003 – Matrices class. The sample size N = 67. My reason is that given the poor correlations between the indicators of motivation and mathematics achievement observed in my dataset, I want to use the same measure of mathematics achievement for all students. This decision is warranted also because the data from the AM 1003 – Matrices class meets the sample size requirements for this analysis.

5.6. Procedures and data analysis

This analysis was conducted using an SPSS macro called PROCESS (Hayes, 2013). From the PROCESS menu screen, the independent variable was motivation (X), the dependent variable (mathematics achievement; Grade100) was (Y), and the mediating variable was intrinsic motivation or extrinsic motivation (M) for the first and second analysis respectively. The motivation variable (X) was computed by summing each student's scores on the six indicators of motivation identified in this dissertation as satisfying the necessary and sufficient conditions for motivating variables: hope, pride, student's academic interest, student's academic achievement goals, personal relevance of learning mathematics, and the importance of mathematics to future career goal of each student. The Cronbach alpha for this scale was computed to be 0.70

5.6.1. A simple mediation analysis – intrinsic motivation as mediator variable

With the PROCESS macro, the model = 4 specification instructs the program to calculate a bootstrapped simple mediation model using the variables indicated; boot=5000 requests 5000 bootstrap samples for estimating the 95% confidence interval for the indirect effects; and total = 1, instructs the PROCESS macro to also estimate and output the total effects in addition to the direct and indirect effects (Hayes, 2013).

5.6.2. Results 1

The result of this analysis (Appendix E) show that the total effect is statistically different from zero (c = 0.21, p = 0.04). The direct effect (c_1 = 0.25, p = 0.07) is greater than the total effect. However, its 95% confidence interval include a zero value (-0.02, 0.53). Thus, this value is not statistically different from zero. For the indirect effect, Hayes (2012, p.13) argued that evidence of indirect effect should not be based on the path coefficients but rather on estimation of the effect itself. This is because this estimation takes into consideration the non-normality of the sampling distribution of the product terms that comprise the indirect effect. For this analysis, the indirect effect has a negative value (-0.04) with a bootstrap confidence interval (-0.22 and 0.13) straddling a zero value. This

result is not statistically different from zero. The output tables for the total, direct and indirect effects are shown below.

Table 5-1. Total, direct and indirect effects table

Total effect of motivation (X) on academic achievement (Y)					
Effect	**SE**	**t-value**	**p-value**	**LLCI**	**ULCI**
0.2138	0.1001	2.137	0.0364	0.014	0.4137
Direct effect of motivation (X) on academic achievement (Y)					
Effect	**SE**	**t-value**	**p-value**	**LLCI**	**ULCI**
0.2532	0.1379	1.8357	0.071	-0.0223	0.5288
Indirect effect of motivation (X) on academic achievement (Y)					
	Effect	**BootSE**	**BootLLCI**	**BootULCI**	
IntMotive	-0.0394	0.0881	-0.2159	0.1274	

5.6.3. A simple mediation analysis – extrinsic motivation as mediator variable

5.6.4. Method

Using the PROCESS macro, I repeated the above analysis. This time, I substituted extrinsic motivation for intrinsic motivation as the mediating variable.

5.6.5. Results 2

The results table (Appendix E) shows that the total effect is statistically different from zero (c = 0.21, p = 0.04). The direct effect (c_1 = 0.27, p = 0.01) is greater than the total effect. Also, its 95% confidence interval excludes a zero value since its lower and upper bounds are (0.07, 0.48) respectively. This result is statistically different from zero. The indirect effect has a negative value (-0.06) and its bootstrap confidence interval do not include a zero value (-0.17, -0.00) as lower and upper bounds respectively. The table of effect values are shown below.

Table 5-2. Total, direct and indirect effects table

Total effect of motivation (X) on academic achievement (Y)						
	Effect	**SE**	**t-value**	**p-value**	**LLCI**	**ULCI**
	0.2138	0.1001	2.137	0.0364	0.014	0.4137
Direct effect of motivation (X) on academic achievement (Y)						
	Effect	**SE**	**t-value**	**p-value**	**LLCI**	**ULCI**
	0.2707	0.1027	2.635	0.0105	0.0655	0.476
Indirect effect of motivation (X) on academic achievement (Y)						
	Effect	**BootSE**	**BootLLCI**	**BootULCI**		
ExtMotive	-0.0569	0.0434	-0.1704	-0.0006		

5.7. A moderated-mediation analysis

This procedure combines the effects of moderation and mediation in a single analysis. Here, both the direct and indirect effects of motivation on mathematics achievement were investigated simultaneously using mathematics self-efficacy belief (W) as the moderating variable. The path diagram is shown in Figure 5-2 above.

With the PROCESS macro, the conditional direct and indirect effects of motivation on mathematics achievement were estimated as coefficients of product terms involving motivation (X) and the moderating variable (W). The number of bootstrap samples for estimating the conditional indirect effects of motivation on mathematics achievement was set as 10,000. To probe the moderating effect of mathematics self-efficacy belief (W), I estimated the direct and indirect effects of motivation on mathematics achievement at the 10, 25, 50, 75, and 90 percentile values of the moderator variable (Hayes, 2013). One can claim evidence of an effect if a given coefficient is statistically different from zero ($p < 0.05$). This analysis was conducted twice, first with intrinsic motivation as the mediating variable and secondly, with extrinsic motivation as the mediating variable. Detailed output of the results are shown in Appendix F. Only the results about the conditional direct and indirect effects are shown in the next sections.

5.8. Moderated mediation with intrinsic motivation as mediating variable

Following the results of my mediation analysis above, the focus of this analysis was on the conditional direct and indirect effect of X on Y and its possible interpretation if it exists. To check for the moderation of the indirect effect, the appropriate results table (Appendix F) is that with outcome variable = IntMotive (intrinsic motivation) and the coefficient of the interaction term is represented as int_1 (Appendix F). The results table shows no evidence of the moderation of the indirect effect since the coefficient of the interaction term for the X → M path (int_1 = -0.004; (a_3 in equation 5 above), p =0.366). Because the first stage of the mediation model was not moderated, the indirect effect would also not be moderated.

To check a moderation of the direct effect, the appropriate results table (Appendix F) is that with outcome variable = Grade100 (mathematics achievement variable) and the coefficient of the interaction term was represented as int_2. The results show that the direct effect was also not moderated because the coefficient of the interaction term (int_2 = 0.022, p = 0.207)

Below are the results of the conditional direct effects of X on Y. The columns show values of the moderating variable (W) estimated at the 10, 25, 50, 75, and 90 percentile values of the moderator, the estimated effect size, the standard error (SE), the t-value, p-value, and the 95% confidence interval of the estimates. We note that while the effect increased in value as the percentile value increased, each has a confidence interval that included a zero value. These results are consistent with the results of the coefficients of their interaction terms as determined above.

Table 5-3. Conditional direct effects of motivation (X) on academic achievement (Y) table

Conditional direct effect(s) of motivation (X) on academic achievement (Y) at values of the moderator(s)						
MSbelief	**Effect**	**SE**	**t-value**	**p-value**	**LLCI**	**ULCI**
19	0.0414	0.1688	0.2454	0.807	-0.296	0.3788
22	0.1084	0.1556	0.6965	0.4887	-0.2026	0.4194
26	0.1976	0.1645	1.2012	0.2343	-0.1313	0.5266
28	0.2423	0.1794	1.3505	0.1818	-0.1163	0.6009
30	0.2869	0.1994	1.4392	0.1551	-0.1116	0.6854

Below are the conditional indirect effects of X on Y. The columns show the mediating variable (intrinsic motivation), the moderating variable (mathematics self-efficacy belief), and the estimated effect sizes at different values of the moderating variable, the bootstrap standard error, and the 95% confidence interval of the estimated effects. For all effects, the corresponding 95% confidence interval includes a zero value. Thus the results are not statistically different from zero.

Table 5-4. Conditional indirect effects of motivation (X) on academic achievement (Y) table

Conditional indirect effect(s) of motivation (X) on academic achievement (Y) at values of the moderator(s):					
Mediator					
	MSbelief	**Effect**	**BootSE**	**BootLLCI**	**BootULCI**
IntMotive	19	-0.0488	0.085	-0.2197	0.1151
IntMotive	22	-0.0453	0.078	-0.2048	0.1028
IntMotive	26	-0.0407	0.0698	-0.1885	0.0883
IntMotive	28	-0.0384	0.0664	-0.1842	0.0807
IntMotive	30	-0.036	0.0634	-0.1795	0.0759

The above analysis was repeated using extrinsic motivation as the mediating variable with similar results (Appendix F). The conditional direct and indirect effects are shown below:

Table 5-5. Conditional direct effects of motivation (X) on academic achievement (Y) table

Conditional direct effect(s) of motivation (X) on academic achievement (Y) at values of the moderator(s):						
MSbelief	**Effect**	**SE**	**t-value**	**p-value**	**LLCI**	**ULCI**
19	0.0075	0.14	0.0539	0.9572	-0.2724	0.2875
22	0.0937	0.1292	0.7247	0.4714	-0.1647	0.352
26	0.2085	0.1438	1.4499	0.1521	-0.0789	0.4959
28	0.2659	0.1613	1.6482	0.1044	-0.0566	0.5884
30	0.3233	0.1834	1.7632	0.0828	-0.0432	0.6898

Table 5-6. Conditional indirect effects of motivation (X) on academic achievement (Y) table

Conditional indirect effect(s) of motivation (X) on academic achievement (Y) at values of the moderator(s):					
Mediator					
	MSbelief	**Effect**	**Boot SE**	**BootLLCI**	**BootULCI**
ExtMotive	19	-0.0149	0.058	-0.1734	0.0602
ExtMotive	22	-0.0306	0.0521	-0.1645	0.043
ExtMotive	26	-0.0515	0.0625	-0.2077	0.0396
ExtMotive	28	-0.062	0.0733	-0.2398	0.0475
ExtMotive	30	-0.0724	0.0862	-0.2798	0.0631

The results of my mediation analysis with intrinsic and extrinsic motivation as mediators, each show direct effects that were greater than the total effect. Also, while the direct effect with intrinsic motivation as mediator was statistically not different from zero, that of extrinsic motivation was statistically different from zero (c = 0.21, p = 0.04; c_1 = 0.27, p = 0.01). The correlation statistics (AM 1003 – Matrices Class) of intrinsic and extrinsic motivation with academic achievement are respectively, 0.14 and -0.14. Both results of my moderated mediation analysis show no statistical evidence of the moderation of either the direct or indirect effect of motivation (X) on mathematics achievement (Y). I will comment on these results later.

5.9. Study 3 – On persistence, self-efficacy belief and motivation

5.9.1. Research design

The research problem is to use the indicators of motivation identified in this dissertation to determine a set that accounts for most of the variation in students' mathematics self-efficacy belief. The methods of data analysis chosen for this investigation are multiple regression and discriminant analysis procedures. The response variable in each case was mathematics self-efficacy belief. The explanatory variables were: intrinsic motivation, extrinsic motivation, self-determination, anxiety about mathematics assessment, personal relevance of learning mathematics, hope, pride, student's academic interests, student's academic achievement goals and the importance of mathematics to the future career goals of each student.

Through a multiple regression procedure, I hope to identify which combination of these explanatory variables account for most of the variation in a student's mathematics self-efficacy belief and the proportion of this variance. Through a discriminant analysis procedure I hope to determine the set of explanatory variables that discriminates amongst groups of students classified as having low and high mathematics self-efficacy beliefs. I expect the results of both analysis might shed some light on the variables that account for differences in mathematics self-efficacy belief amongst students. The sample size for both analyses is the same as the dissertation sample (N = 121 students). This sample was chosen because students' academic achievement (grades) was not required data for each analysis.

5.9.2. A stepwise multiple regression procedure

The goal of this analysis was to identify the set of explanatory variables that account for most of the variation in mathematics self-efficacy belief. With no prior knowledge or assumptions about what variables might matter, I used a stepwise multiple regression procedure to determine the set of variables that accounts for most of the variation in mathematics self-efficacy belief, and the proportion of this variance.

5.9.3. Results

The results show that the overall model was statistically significant ($F_{4,116} = 47.77$, $p < 0.001$). The Model Summary Table (below) and its footnotes show the variables used in the regression model, their entry sequence, The R^2 and the Adjusted R^2 values and the contribution of each of the explanatory variables as it entered the analysis. The table also indicates that the variables used in the model were hope, student's academic achievement goal, pride, and student's academic interest.

Table 5-7. Model Summary table

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.657[a]	.431	.427	3.812	.431	90.270	1	119	.000
2	.725[b]	.525	.517	3.499	.094	23.241	1	118	.000
3	.759[c]	.577	.566	3.317	.052	14.324	1	117	.000
4	.789[d]	.622	.609	3.147	.046	13.972	1	116	.000

Dependent Variable: MSbelief Model 1. Predictors: (Constant), Hope; Model 2. Predictors: (Constant), Hope, AchGoal; Model 3. Predictors: (Constant), Hope, AchGoal, Pride; Model 4. Predictors: (Constant), Hope, AchGoal, Pride, Interest;

These four variables, all classified as motivation variables in this dissertation, account for 62.2% of the variation in student's mathematics self-efficacy belief. Coefficients in Table 5-8 (below) show both the unstandardized and standardized coefficients of the variables in the respective regression models.

Table 5-8. Coefficients table

Model		Unstandardized Coefficients		Standardized Coefficients	t-value	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	8.033	1.813		4.431	.000	4.443	11.623
	Hope	1.074	.113	.657	9.501	.000	.850	1.298
2	(Constant)	1.193	2.187		.545	.587	-3.138	5.524
	Hope	.712	.128	.435	5.558	.000	.458	.966
	AchGoal	.327	.068	.378	4.821	.000	.193	.462
3	(Constant)	-.453	2.118		-.214	.831	-4.648	3.742
	Hope	.470	.137	.287	3.423	.001	.198	.742
	AchGoal	.305	.065	.351	4.709	.000	.176	.433
	Pride	.411	.109	.281	3.785	.000	.196	.626
4	(Constant)	-3.440	2.163		-1.590	.114	-7.724	.844
	Hope	.293	.139	.179	2.115	.037	.019	.567
	AchGoal	.221	.065	.255	3.381	.001	.091	.350
	Pride	.438	.103	.299	4.236	.000	.233	.642
	Interest	.229	.061	.275	3.738	.000	.108	.350

a. Dependent Variable: MSbelief

5.9.4. A discriminant analysis procedure

My expectation is that for a variable like mathematics self-efficacy belief, one could group a large body of students into three categories representing low, average, and high mathematics self-efficacy beliefs. However, because of the distribution of students' scores on mathematics self-efficacy belief in this sample, I settled for two categories - high mathematics self-efficacy belief (HMSELFB) and low mathematics self-efficacy belief (LMSELFB). Initially, I set the range for LMSELFB as scores <= 22 on the mathematics self-efficacy belief scale and high mathematics self-efficacy belief (HMSELFB) with scores 23 and greater. However, this scheme yielded disproportionate cases for the two categories with 21 cases as LMSELFB and 100 cases for HMSELFB. As a result, I revised the scheme to seek more equal group sizes, finally settling on bins defined by scores <

25 to describe students with low mathematics self-efficacy belief (LMSELFB) and scores ≥ 25 as describing students with high mathematics self-efficacy belief (HMSELFB).

This scheme yielded 51 and 70 cases for the two groups respectively. Also, for this analysis, there were ten explanatory variables. I did not expect all ten variables to be statistically identifiable in discriminating the groups. The goal was parsimony, to determine an optimal set of explanatory variables that discriminates the two groups. With no prior knowledge of what variables might be more useful than others, I used a stepwise procedure with method=forward. The criterion for variables to enter or be removed from the analysis was left at the default values (F-to-enter = 3.84 and F-to-remove = 2.71)

5.9.5. Results

Table 5-9 (below) show a statistically significant difference ($p \leq .05$) in the group means of all variables except anxiety about mathematics assessment (Manxiety) and personal relevance of learning mathematics (Usefullness).

Table 5-9. Tests of equality of group means table

	Wilks' Lambda	F-value	df1	df2	Sig.
Hope	.819	26.307	1	119	.000
Pride	.795	30.636	1	119	.000
CareerG	.895	14.016	1	119	.000
Interest	.802	29.305	1	119	.000
ExtMotive	.927	9.359	1	119	.003
IntMotive	.825	25.322	1	119	.000
Manxiety	.979	2.523	1	119	.115
Usefullness	.983	2.114	1	119	.149
MSdeterm	.901	13.040	1	119	.000
AchGoal	.790	31.580	1	119	.000

These two variables have $p = 0.115$ and $p = 0.149$, respectively. The Box's M test of the null hypothesis that there was no statistically significant difference in the covariance matrices formed by the two bins was significant (F-value = 2.84, p-value < 0.05). However, because the group sizes were neither very small nor extremely unequal, this violation of Box's M test may reduce the statistical power of the analysis but it will have little effect with respect to increasing the risk of a type 1 error (Warner, 2013). For this reason, this result was ignored.

A canonical correlation describes the correlation between multiple predictor variables and the discriminant function produced in this analysis. Its value was 0.58 indicating that 33.52% (R^2) of the discrimination between groups defined in terms of mathematics self-efficacy belief was accounted for by these variables.

Wilks' Lambda identifies that there is a statistically significant discriminant function ($p < 0.001$) with 66.50% of the variance in mathematics self-efficacy belief not explained by the predictor variables.

The standardized canonical discriminant function coefficient (weights) of each variable in a discriminant function equation is shown in Table 5-10 (below).

Table 5-10. Standardized canonical discriminant function coefficients

	Function
	1
Pride	.561
Interest	.456
AchGoal	.386

The structure matrix shown in table 5-11 suggests how the discriminant function might be named. It displays the correlation of variables with the discriminant function in order of their weights: student's academic achievement goal, pride and student's academic interests. This result along with the result of the multiple regression analysis where 4 of the 6 motivation variables identified in this dissertation (hope, student's academic achievement goal, pride, and student's academic interest) accounted for 62.2% of the variation in mathematics self-efficacy belief, suggests that one's motivation manifested through her values, interests, desires, goals (value and significance variables) might account for persistence often associated with self-efficacy belief; that the more one's values, or goal and desires are at stake, the more likely she would persist in pursuit of a goal.

Table 5-11. Structure Matrix table

	Function
	1
AchGoal	.726
Pride	.715
Interest	.699
Hope[a]	.668
IntMotive[a]	.594
CareerG[a]	.499
Usefullness[a]	.449
MSdeterm[a]	.416
Manxiety[a]	.268
ExtMotive[a]	.220

The structure matrix table describes the correlation of each indicator with the discriminant function. For example, this table show that student's academic achievement

goals, pride, and student's academic interest are positively correlated with the discriminant function 1 with values 0.73, 0.72, and 0.70 respectively.

Table 5-12 shows that 78.5% of the cases were classified correctly.

Table 5-12. Classification results table

			Predicted Group Membership		
		CMSELFB	0	1	Total
Original	Count	0	33	18	51
		1	8	62	70
	%	0	64.7	35.3	100.0
		1	11.4	88.6	100.0

a. 78.5% of original grouped cases correctly classified.

Chapter 6.

Conclusion

6.1. Introduction

The motivation questionnaire is the foundation of many studies that investigate motivation and academic achievement. To advance our understanding of the relationship between motivation and academic achievement, it is important that researchers and educators start from the same place; that they make the same initial assumptions about indicators of motivation. This requires that they agree on how to constitute the motivation questionnaire. I addressed the question of how to constitute a motivation questionnaire in Chapter 2. I also argued that intrinsic motivation and extrinsic motivation through their definitions, are nominal variables rather than indicators of motivation as claimed in the literature (Glynn & Koballa, 2006). I will revisit these issues in this chapter and also, comment on the results of my mediation and moderated mediation analysis (Study 2).

The relationship between mathematics self-efficacy belief and academic achievement has become an important and growing area of the research on motivation and academic achievement (Pajares & Miller, 1994). The impetus for this research might be the following statements (Bandura & Locke, 2003, p. 87)

> Among the mechanisms of human agency, none is more central or pervasive than beliefs of personal efficacy. Whatever other factors serve as guides or motivators, they are rooted in the core belief that one has the power to produce desired effects; otherwise one has little incentive to act or to, persevere in the face of difficulties.

Central to this view is the nature of the relationship between self-efficacy belief, persistence, and motivation. I will use the results of my multiple regression and discriminant analysis procedures (Study 3), and control value theory (Pekrun et al., 2006, 2009; Pekrun, Frenzel, Goetz, & Perry, 2007) to explore the relationship between mathematics self-efficacy belief, persistence, and motivation. The result of my investigation of the relationship between the eleven indicators of motivation and mathematics achievement (Study 1), showed unexpected results with respect to the

variance in mathematics achievement explained by the explanatory variables. I will comment on this result. I will end this chapter with my conclusions, thoughts on some issues in the research literature that caught my attention and some limitations of this research framework with respect to their use for investigating the relationship between motivation and academic achievement, and a suggestion for future studies.

6.2. On the properties of indicators of motivation and the motivation questionnaire.

> A tree is known by its fruit (Luke, 6:43-45, p. 215, Contemporary English Version)

The question of whether a variable is a motivating variable or not is a theoretical problem. This is not a problem that we should address using the results of empirical studies. All objects, physical or conceptual have properties. The properties of an object uniquely characterize the object and allow us to distinguish one object from another. Through object properties, a variable is either a motivating variable, or it is not. It cannot be so for one researcher but not for the other. For these reasons, this dissertation argues that to classify the variables in a motivation questionnaire, we must turn to their properties; to what each variable does and its role in a student's quest for academic achievement. This is because what each variable does, the role it plays in a student's quest for academic achievement is implicitly determined by its properties (Gowers, 2002).

While different researchers may debate what these properties are or should be, it seems unlikely that researchers would argue the importance of a consistent motivation questionnaire for investigating the relationship between motivation and academic achievement; that given a set of variables, that all researchers and educators should choose the same set of motivating variables. Also, it seems unlikely that one would deny that the search for one may be realized through the properties of objects. With object properties in focus, the question of how to constitute a motivation questionnaire effectively reduces to the question of what categories of variables do we need in a motivation questionnaire to give plausible accounts of the observed differences amongst students with respect to their academic activities.

Using social cognitive theory, Bandura (2001) distinguished between two categories of variables: intention variables and action variables. He argued that while the two categories are functionally related, they are separated in time. With Fowler and Fowler (1995), Bryan, et al. (2011), and Lazarus (1991), this dissertation identified two conditions as necessary and sufficient conditions for motivating variables, and argued that intention variables satisfy the necessary and sufficient conditions for motivating variables. The intention variables are the motivating variables of academic achievement. I also argued that the action variables in a motivation questionnaire, through their time separation from the intention (motivation) variables, are process (activity) variables.

As teachers and educators, we know that our students differ with respect to how they might engage the same academic activity. That is our lived experience. They may also be gender differences, differences in academic ability, and differences in academic preparation, etc. Each of these differences is real, potentially important and worthy of consideration for inclusion in a theoretical model that aims to investigate the relationship between motivation and academic achievement. This dissertation argues that we may account for these kinds of differences amongst students through a distinction in the functional role(s) of the variables in a motivation questionnaire. Based on properties of the eleven indicators of motivation identified in this dissertation, this dissertation classified these variables into three categories namely: motivators, mediators and moderators; and argued that all three categories are required components of a motivation questionnaire and, thus, a theoretical model that seeks to investigate the relationship between motivation and academic achievement.

Motivation variables (motivators) are those variables that may initiate and sustain goal pursuit. They embody one's collective intentions including attitude and commitment to a goal. Students may differ in their goal commitment through a difference in their motivator variables. Also, through a direct relationship with a goal, changing motivator variable(s) may change the likelihood that one may realize a goal. The action variables, as future events with respect to a goal, do not have a direct relationship with a goal. The action variables are those variables that may be called upon during an activity, to realize a goal. Action variables may be mediators or moderators. Moderator variables address the question of *when* an effect may occur while mediator variables address the question

of *how* the effect may occur (Jose, 2013). Also, because a mediator may be an interval variable or a categorical variable, a mediator variable may also be used as a moderator. Thus, the distinction between a mediator and a moderator is that of property; on what role a variable is playing within the context of a student's academic achievement.

The theoretical study of this dissertation and its proposed research framework differs from similar studies in the literature through its statements on the necessary and sufficient conditions for a variable to be deemed a motivating variable (Glynn, et al., 2009; Kim, et al., 2012, & Pintrich & de Groot, 1990). With these conditions, this dissertation sets a standard that anyone could use to check any claim that a variable is a motivating variable. Also, the proposed framework differs from related frameworks in the literature through its classification of the indicators of motivation into categories namely as motivators, mediators, and moderators. This classification was both important and required because it allows an investigation of the effect of treatments; of different ways that one might engage an academic activity (mediation). It also allows an investigation of the effect of moderation; this may include gender effect, differences in academic preparation, differences in socio-economic background, etc. With these allowances, the framework proposed by this dissertation expands the range of research possibilities that we could use to investigate the relationship between motivation and academic achievement.

6.3. On intrinsic and extrinsic motivation as motivation variables

With the properties of motivating variables identified in this dissertation as guide, this dissertation argued that each of intrinsic and extrinsic motivation did not satisfy the property of motivating variables. Intrinsic and extrinsic motivation was classified as mediators of academic achievement. There may be disagreements over this claim. However, a good starting point for one to argue that intrinsic and extrinsic motivation are motivation variables, might be to first, clarify whether these variables are *activity variables* namely: intrinsically and extrinsically motivated *learning activities or goal variables* namely: intrinsically and extrinsically motivated *reasons for learning.* This clarification is both important and required because it is not self-evident through the definition and

measurement of these variables in books, the research literature, and various motivation questionnaires.

Below are definitions and measures of intrinsic and extrinsic motivation taken from a book and a motivation questionnaire

> Intrinsic motivation refers to motivation to engage in an activity for its own sake. People who are intrinsically motivated work on tasks because they find them enjoyable. Task participation is its own reward and does not depend on explicit rewards or other external constraints (Schunk, et al., 2008, p.236).

Intrinsically motivated mathematics learning (Glynn & Koballa, 2006**,** p. 29-31)

(I) I enjoy learning mathematics.

(ii) The mathematics I learn is more important to me than the grade I receive.

(iii) I find learning mathematics interesting.

(iv) I like mathematics that challenges me.

(v) Understanding mathematics gives me a sense of accomplishment.

> Extrinsic motivation is motivation to engage in an activity as a means to an end. Individuals who are extrinsically motivated work on tasks because they believe that participation will result in desirable outcomes such as a reward, teacher praise, or avoidance of punishment (Schunk, et al., 2008, p.236).

Extrinsically motivated mathematics learning (Glynn & Koballa, 2006, p. 29-31)

(I) I like to do better than the other students on mathematics tests.

(ii) Earning a good mathematics grade is important to me.

(iii) I think about how learning mathematics can help me get a good job.

(iv) I think about how my mathematics grade will affect my overall grade point average.

(v) I think about how learning mathematics can help my career.

Per definitions presented here, this dissertation claims that intrinsic and extrinsic motivation are activity variables, *different ways of learning*. Through their measurements, intrinsic and extrinsic motivation are measured as goal variables; *different reasons for learning*. Below, I will argue that irrespective of whether one interprets intrinsic and

extrinsic motivation as different ways of learning (activity variables), or as different reasons for learning (goal variables), these variables through their definition, lack the property of motivating variables. Also, I will re-state other difficulties that might arise from the definition of these variables, especially with respect to their continued use in motivation questionnaires as separate motivation variables.

6.4. Intrinsic and extrinsic motivation as activity variables

Brophy (2004, p.4) distinguished between goals and strategies when he stated that strategies are methods that one might take to achieve desired goals and satisfy motives. As different ways of learning, intrinsic and extrinsic motivation are methods. These variables might be perceived as deep learning for intrinsic motivation and surface learning for extrinsic motivation. One advantage of this classification as deep and surface learning is that it is consistent with their definition. Also, as deep and surface learning, these variables have consistent properties. For example, one can state *a priori*, the properties of deep or surface learning independent of whether one uses them or not and also, independent of one's reasons for engaging in them. However, a difficulty with this strict categorization is that one might engage in deep learning for extrinsic benefits. For example, an employee who wants to impress her boss for promotion may not succeed with surface learning as the boss might require a detailed knowledge of processes and procedures. However, this difficulty appears to arise from the definition of intrinsic and extrinsic motivation, rather than from a limitation of the properties of deep or surface learning. On the question of whether as different ways of learning, intrinsic and extrinsic motivation may be classified as motivating variables, this dissertation answers no and here is why.

As different ways of engaging an academic activity, different ways of learning, each variable, intrinsic or extrinsic motivation, serves a different purpose. This is stipulated in their definition. Thus, reasonable people pursuing different objectives might have good reasons to choose one over the other to achieve specific learning or career goals. For this reason, these variables have nominal properties (failed property 1 of motivating variables namely, ordinal property). For one to deny that these variables have nominal property, one would have to either discount people's reasons for the choice they made or

deny that the definition of intrinsic and extrinsic motivation are valid definitions of these variables.

Furthermore, because they are activity variables, they are future events with respect to a given goal (failed property 2 of motivating variables: as future events they lack the motivating property of motivating variables namely, the capacity to induce action). They failed property 2 because as activity variables, they are usually called upon to achieve a goal. Thus, they played no role either in initiating or sustaining any goal pursuit.

Also, as different ways of engaging an academic activity, with each serving a specific purpose, we may compare these variables to a pen and a pencil; a car and a truck. This implies that while one may alternate between one and the other from one activity to the next, one is not expected to use both at the same time. Through the definitions of intrinsic and extrinsic motivation, one expects that a student may alternate between intrinsic and extrinsic motivated learning from one activity to the next one. However, a student is not expected to use both methods at the same time to engage a learning activity. This follows from the definition of these variables. This observation if confirmed has implications with respect to the continued use of intrinsic and extrinsic motivation as separate and independent variables in motivation questionnaires for quantitative research purposes.

Another difficulty arising from the definition of these variables is because their definitions references external objects as reasons for learning, it is not apparent how one might distinguish between students engaged in intrinsically or extrinsically motivated learning. The definition of these variables offers no clue on how we might distinguish one method of learning from the other. While these questions might not be directly related to whether intrinsic and extrinsic motivations are motivating variables, there are questions we have to ask because they follow from the definition of these variables.

6.5. Intrinsic and extrinsic motivation as goal variables

As goal variables, intrinsic and extrinsic motivations are different reasons for learning. As different reasons for learning, these variables have nominal property (failed

property 1 of motivating variables namely, ordinal property). One might argue that if each variable (intrinsic or extrinsic motivation) is considered separately, then it may satisfy the property of motivating variables through its reference to reasons for learning. A counterargument might be that considering them separately would constitute a departure from current norms, and we need a theoretical justification for that. Finding none, I will reject this suggestion. But even so, the following variables were identified as motivation variables in this dissertation: hope, pride, student's academic interest, student's academic achievement goals, personal usefulness of learning mathematics, and the importance of mathematics to the future career goals of each student. The external reasons for learning referenced in the definition of each of intrinsic and extrinsic motivation are variables that we independently identified in this dissertation as motivating variables. For example, hope, pride, student's academic interest, personal usefulness of mathematical learning may be considered as *intrinsic reasons for learning*. Also, a student's academic achievement goals, and the importance of mathematics to the future career goals of each student, may be considered as *extrinsic reasons for learning*. For this reason, there appears to be no theoretical justification for duplicating some of these variables with the addition of any or both intrinsic and extrinsic motivation in a motivation questionnaire as motivation variables. Also, because they are activity variables, instantiated only when one engages an activity, they differ from the six variables that we independently identified in this dissertation as motivation variables.

Furthermore, because intrinsic and extrinsic motivation are activity variables, we do not know in advance which of the two variables, one may use to engage an academic activity. This information becomes available only through measurement, during an activity when data might be collected from research participants. What we do know is that a student is not expected to use both variables for the same activity. This implies that we may not (unless one has specific reasons to do so) collect data for both variables from a research participant, for the same activity. Collecting data for both variables for the same activity is not consistent with the definition of these variables. In addition, if we were to collect data for both variables for the same activity, it may not be clear which variable a student used to engage the activity and also, how to quantitatively describe this data. This constraint implies that both variables may not be represented in a motivation questionnaire as separate and independent motivation variables.

In spite of the challenges cited above, this dissertation recognizes or expects that any academic activity may have an intrinsic and extrinsic component for a student; that both are not necessarily mutually exclusive as suggested by the definitions of intrinsic and extrinsic motivation. The difference between students for different activities might be that of degree; the proportion of intrinsic or extrinsic reasons for engaging in a given activity. Thus, the suggestion implicit in the definition of these variables that knowledge acquired for enjoyment is devoid of gain or that knowledge acquired for gain is devoid of enjoyment is likely, not consistent with our reality. This observation is another strong counterargument against considering each of these variables separately because that would reinforce the suggestion that one cannot pursue an activity for intrinsic and extrinsic benefits simultaneously; that both benefits are not available to anyone during an activity as implied by the definition of intrinsic and extrinsic motivation.

The difficulties with the simultaneous use of intrinsic and extrinsic motivation as separate variables in a motivation questionnaire as claimed by this study, is further evidence that these variables as currently defined, lack the properties of motivating variables.

For all the above reasons, this dissertation concludes that whether intrinsic and extrinsic motivation are interpreted as different ways of learning, or as different reasons for learning, their nominal property stipulated in their definition, represents them as a category of variables. Also, it restrains us from collecting data for both variables for the same activity and through this, it implicitly denies any claim that intrinsic and extrinsic motivation might satisfy the properties of motivating variables.

6.6. On mediation and the results of moderated-mediation analysis

The intent of the mediation analysis conducted in this dissertation was to address the following question:

> If intrinsic and extrinsic motivations by their definitions are different ways of engaging an academic activity, how might their effects be manifested and how could we describe these effects theoretically?

We may imagine the effect of motivation (X) on academic achievement (Y) as a vector field (diagram (A), Figure 6-1 below). Its magnitude is given by the regression weight of motivation (X) on academic achievement (Y). The direction of the effect of motivation on academic achievement may be described by its line of action; here, from motivation to academic achievement; its point of application is on the motivation variable (Gross, Hauger, Schroder, Wall & Rajapakse, 2013). As vector path diagrams, diagram (A) describes the total effect (c) of motivation on academic achievement. Also, in Figure 6-1 below, diagram (B) describes a mediation process while diagram (C) describes a reverse mediation process.

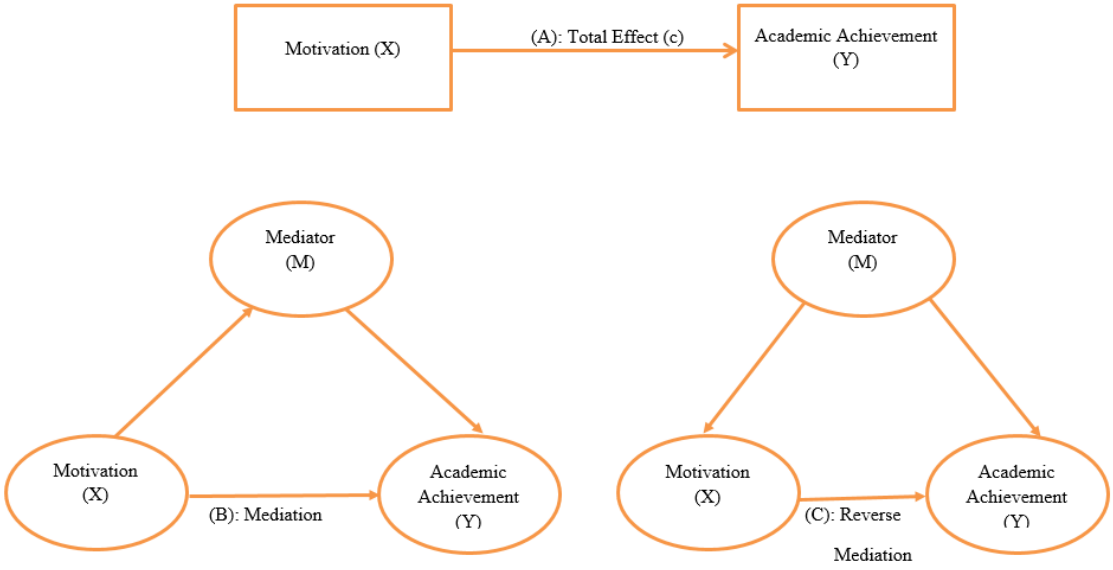

Figure 6-1. Vector representation of mediation and reverse mediation

We note that in path diagram (A), variable X (motivation), has only one path to transmit its effect on Y (academic achievement). For diagram (B) (mediation diagram), the effect of motivation (X) on academic achievement (Y) has two paths to follow. The X → Y path (direct effect) and the X → M → Y path (indirect effect). If the flow through the X → M → Y path is greater than zero and significant, we have mediation. In principle, we can drive the direct effect to zero (achieve total mediation) by adding more paths for transmitting the effects of X → Y (Howitt & Cramer, 2005; Warner, 2013, Jose, 2013).

For a reverse mediation (diagram (C)) we restrict the transmission of the effect of motivation on academic achievement (X → Y) to only one path. This is equivalent to path

diagram (A) (where total effect= c). Thus, the direct effect (c_1) starts off being equal to the total effect (c) . An additional effect from the mediator to motivation (M → X) path adds to the existing direct effect. If this additional effect is greater than zero and significant, we have a reverse mediation ($c_1 > c$). In a statistically significant reverse mediation analysis, we should expect the motivation to academic achievement (X→ Y) and the mediator to motivation (M→ X) paths to have positive weights. The mediator to academic achievement (M → Y) path may have a negative weight to balance the path equations. Again, in principle we can increase the direct effect of motivation (X) on academic achievement (Y) by using multiple predictors of motivation (X). These multiple predictors of motivation (X) transfer their effects to X and, through X, to Y. The magnitude of the indirect effect (the difference between the total and direct effects) would be the strength of the mediating variable (Jose, 2013).

The result of my mediation analysis using intrinsic and extrinsic motivation as mediating variables was mixed. With intrinsic motivation as the mediating variable, the total effect ($c = 0.21,\ p = 0.04$) and the direct effect ($c_1 = 0.25, p = 0.07$).While the direct effect was greater than the total effect as one might expect with intrinsic motivation as the mediating variable, its $p > 0.05$ and thus, statistically not different from zero. With extrinsic motivation as mediating variable, the total effect ($c = 0.21,\ p = 0.04$) and the direct effect($c_1 = 0.27, p = 0.01$). Here, the direct effect is statistically not zero. In the research literature (Jose, 2013) results similar to my mediation analysis with extrinsic motivation and where the mediating variable (M), as in this case, was negatively correlated with the dependent variable (Y) has often been described as spurious and indicative of a misleading relationship between the mediating variables; the so-called suppressor effect. There are many definitions of suppressor variables and also, different types of suppressor variables. For example, Gaylord-Harden, Cunningham and Grant (2010, p. 845), identified three types of suppressor effects. However, while some researchers argue that suppression is a false and misleading relationship between the variables, others argue that suppression might be due to important and unidentified relationships between the variables (Jose, 2013, Warner, 2013).

This dissertation argues that there is nothing misleading or false in the expected relationship between intrinsic or extrinsic motivation, motivation, and mathematics

achievement. Intrinsic and extrinsic motivation variables are expected to be positively correlated with motivation and through motivation, to mathematics achievement. We can also argue that motivation is expected to be positively correlated with mathematics achievement. Thus, notwithstanding the present results, this dissertation argues that if we imagine mediation and reverse mediation path diagrams as a triangle of vectors in equilibrium, a theoretical argument that accepts mediation is not likely to deny reverse mediation. That the feasibility of path (B), the mediation triangle, implicitly assures the feasibility of path (C), the reverse mediation triangle (Howitt & Cramer, 2005; Hayes, 2013; Rose, 2013; Warner, 2013,). For one to accept mediation (diagram (B)), and deny reverse mediation (diagram (C),) she would be claiming that the vector path X to M is favoured over the vector path M to X, irrespective of the relationship between the variables at the nodal points.

The results of my moderated-mediation analysis show path coefficients that were not statistically different from zero. These statistically non-significant path coefficients may be due to the small sample size and lack of sufficient data points at each of the estimation intervals. Again, using theoretical arguments, one expects that differences in levels of mathematics self-efficacy belief amongst students might have an impact on their mathematics achievement. More study is required to improve our understanding of this process (Hayes, 2013; Jose, 2013; Warner, 2013).

6.7. On persistence, self-efficacy belief, motivation and academic achievement

The core argument of self-efficacy theory (Bandura, 2001, p.10) – that unless one believes that she has the power to produce a desired outcome or forestall an undesirable one, she has little incentive to persevere in the face of difficulties – is not in dispute. The question posed and investigated in this study is as follows:

> What is the relationship between self-efficacy belief, persistence, and motivation? Given self-efficacy belief, given a declaration of one's competence with respect to an activity, can we infer persistence or, given one's motivation with respect to an activity, can we infer persistence?

These are important questions to ask within the context of the research on the relationship between motivation and academic achievement. This is because much research on motivation and academic achievement focuses on the impact of self-efficacy belief on academic achievement (Pajares & Miller, 1994, Beghetto & Baxter, 2012). This dissertation argues that while a claim of self-efficacy belief as a driver of persistence may account for differences in persistence amongst different people for the same activity, it struggles with a plausible account of why the same person might demonstrate different levels of persistence for different activities.

This dissertation claims that if we conceive of persistence as a resource, a time resource, then, differences in persistence might suggest differences in effort and through effort, to differences in time commitment. The implied suggestion here is that one is not likely to invest a lot of time on something that is not important because that would be time taken away from more important things. Thus, through opportunity costs of time investments, this dissertation argues that while self-efficacy belief might be an important measure of the likelihood of success in an endeavour, it is not the driver of one's persistence.

Another difficulty with a claim of self-efficacy belief as a driver of persistence, is that through its definition and also, through Bandura's (2001, p.10) arguments, the relationship between self-efficacy belief and persistence appears to be limited to those cases where one has little or no doubt about her ability or inability to complete a task. In this respect, self-efficacy belief appears to exclude those rare but important cases in human history where one might not know how to accomplish a task; where one is unsure about how to proceed and also, where one may have strong self-doubts about the possibility of success. Some recent examples include the scientists who worked on the Manhattan project, the civil rights activists in the United States, South Africa, and India. My claim is that, in general, we do not know what we can or cannot do, until we are put to a test, sometimes by circumstances beyond our control. Events in our recent history, some mentioned above, support this claim. I claim that self-efficacy belief through its definition, may not account for those rare but important cases in our history, where one had strong self-doubts about the possibility of success, was unsure about how to proceed and may even be fearful for her life but, where in the fighting songs of the civil rights

activists in the United States; she would not allow anybody to turn her around; when giving up was not an option. The question then is for these rare cases, what are the variable(s) that drive one's persistence? Some may argue hope, pride, etc. I claim that self-efficacy belief through its definition is not likely the driver of one's persistence for these cases.

I also claim that while the examples above may appear to be special cases, that they are indeed, the general case and include instances where people are sure or know how to complete a task; that is, instances of strong self-efficacy belief as a special case. This claim rests on the premise that a strong self-efficacy belief is not a given, it is not a gift that some people receive at birth, and others don't. It was likely acquired through effort and hard work potentially driven by factors like interest, perceived usefulness, achievement goals, etc. Also, the variation of self-efficacy belief amongst students for different courses appears to support this claim (Denissen, Zarrett & Eccles, 2007; Goetz, Frenzel, Pekrun, Hall & Ludtke, 2007). If a strong self-efficacy belief was earned, then one may ask why do some people earn it and others don't? Also, why do students appear to earn it in different subject areas? (Liem & Martin, 2012)

The results of my stepwise multiple regression analysis with ten predictor variables using mathematics self-efficacy belief as a response variable indicates that four of the motivation variables identified in this dissertation namely: hope, pride, student's academic achievement goals, and academic interest accounts for 62.2% of the variance in mathematics self-efficacy belief. The results of my discriminant analysis using the same ten explanatory variables indicate that three of the motivation variables identified in this dissertation namely: pride, student's academic achievement goals, and student's academic interest, discriminate between students with low and high mathematics self-efficacy belief. These two results taken separately and collectively, suggest that persistence may be about one's want and needs. That persistence is likely driven by value and significance variables; by motivation variables. It is part of our human experience, that in general, people would persist on things that are important to them even when they are unsure about how to proceed, and even when they have strong self-doubts about their ability to succeed.

Also, in general, people may likely be less persistent about things that are less important to them. The results of this dissertation when combined with domain variation of self-efficacy beliefs amongst students might account for why students differ in where and when they demonstrate strong self-efficacy belief. When people convince themselves of the right thing to do or what they want to do, it is very likely that they will summon the necessary resources to do it.

On the question of the relationship between self-efficacy belief, persistence, and motivation, I argue as follows: Persistence is an outcome variable. Thus, this question reduces to whether one can infer persistence given self-efficacy belief or infer persistence given motivation. From the results of this dissertation (Study 3) and the control value theory of achievement emotions, and its two appraisals, (Pekrun & Stephens, 2009, 2010) we may construct a 2 by 2 table for control (mathematics self-efficacy belief) and value and significance variables (motivation) as shown below.

Persistence, effort, value and significance →

	Appraisal of value & significance	
Appraisal of control	**Strong value & significance**	**Low value & significance**
Strong self-efficacy belief and control over task activities	Strong self-efficacy belief and strong high value and significance.	Strong self-efficacy belief but low value and significance
Low self-efficacy belief and limited control over task activities	*Low self-efficacy belief but strong value and significance.*	Low self-efficacy belief, and low value and significance.

Figure 6-2. A 2 X 2 cross tabulation of task control and value and significance

For any row of this table, one's competence, one's mathematics self-efficacy belief may be deemed constant. However, the value and significance variables and thus, persistence and effort, decreases left to right. This suggests that for any measure of self-efficacy belief, that value and significance variables drive one's effort and one's persistence.

This observation is in line with our human experience when we imagine time as a resource; one cannot postpone time nor pause it. Then imagine persistence as time. All other things being equal, the more persistent one is, the more effort she makes, the more work she does, and more time investment she commits to an activity. Also, given that time spent on an activity is time not available for another activity, it follows that one is more likely to spend time on things that are important to her; that value and significance variables (motivation variables) are drivers of one's persistence. Thus when things are important, one is more likely to spend more time, make more effort to achieve it. When things are less important, even when they are within reach and sometimes, easily achievable, one may not make the necessary effort to achieve it. This might be because time spent pursuing less important things, is time not available to pursue more important ones.

This dissertation concludes that given self-efficacy belief; given a declaration by one of her competence with respect to an activity, that we cannot infer her persistence. Why? Because a declaration of competence does not in any way indicate one's interest, desire, etc., with respect to the activity. It does not indicate one's commitment to the activity. It is simply, a declaration of capacity; a declaration of potential. However, given one's motivation with respect to an activity, one can infer persistence. Why? Because motivation for an activity indicates one's collective intentions and commitment to an activity. I conclude that it is the value and significance variables, the motivation variables that drive our persistence and our efforts; that persistence might be a reflective indicator of motivation. Also, because persistence correlates with effort and thus, to amount of work done to accomplish a task, that effort might also be a reflective indicator of motivation. If we imagine effort as a demonstration of one's self-efficacy belief with respect to an activity, then persistence and/or effort might be a measure self-efficacy belief with respect to an activity. This might be very different from perceived or declared self-efficacy belief.

6.8. On the unexpected correlation and multiple regression results (Study 1)

The reliability statistics generated for the sample used in this dissertation are consistent with those from similar studies reported in the literature. For example, Pekrun, Frenzel, Goetz, and Perry (2007); Pekrun and Stephens (2009) and Pekrun, et al. (2011) on academic achievement emotions; (Glynn, & Koballa, 2006; Glynn, et al. 2009), on the science motivation questionnaire variables, and (Harackiewicz, et al, 2008), for academic interest and academic achievement goals variables. The correlation statistics amongst the eleven explanatory variables were as expected with values ranging from 0.24 to 0.66. Because each variable is an indicator of motivation, each is expected to account for different aspects of the motivation construct. For this reason, these variables were not expected to be strongly correlated with each other and the results reported here are consistent with similar results in the research literature. The negative correlation statistic observed between personal relevance of learning mathematics and academic achievement was unexpected. However this result appears to be consistent with that reported by Pekrun, Elliot and Maier (2006, p. 586) where students' GPA was negatively correlated with a mastery goal orientation.

Also, the negative correlation between extrinsic motivation and academic achievement observed in this study was not expected. However, this result appears to be consistent with the results of similar studies. For example, Areepattamannil, Freeman, and Klinger (2011) explored the relationship between intrinsic, extrinsic motivation and academic achievement amongst Indian adolescents in Canada and those in India. They reported that extrinsic motivation was negatively correlated with academic achievement ($\beta = -0.18$, $p < 0.001$) for Indian immigrant adolescents in Canada. For their counterparts in India, extrinsic motivation was not a significant predictor of academic achievement ($\beta = 0.07$, $p = 0.24$). They wrote that the results of their study were in agreement with the negative association between extrinsic motivation and academic achievement (p. 434-435).

The data for this dissertation were collected from students enrolled in six departments in the faculty of science at the University of Colombo who took the AM 1003

Matrices and AM 2002 Numerical Analysis courses. While the negative correlation of student's grades with personal relevance of learning mathematics was unexpected, on second thought and given the number of student departments (six) and the number of students sampled (N = 121), it may not be difficult to conceive a situation where many of the students in the sample may differ with their curriculum designers about the usefulness of some of their required mathematics courses.

The low variance in student's academic achievement accounted for by all explanatory variables was unexpected at 6.5%. Because of this low variation, the regression results (Study 1) from this dissertation did not shed any light on the research questions that it was intended to address. More work would be required to answer these questions.

This dissertation advanced the cause of theoretical studies in education in two important ways. First, it signals a shift; a "hard science" shift for theoretical studies in education. For example, in the research literature, intrinsic and extrinsic motivations are identified as motivation variables with ordinal property (Glynn, et al., 2006; 2009; 2011). However, through their definitions, they have nominal properties (Schunk, et al., 2008, p. 236). With the properties of motivating variables identified in this dissertation as guide, this dissertation argued that intrinsic and extrinsic motivation are not motivating variables; that they are nominal variables with nominal properties. The theoretical arguments for this claim rests on the premise that when we define a variable, we must also admit all properties implicit in or, could be derived from that definition.

Secondly, this dissertation imagined a mediation path diagram as a triangle of vectors in equilibrium and argued that a transfer of effect from an exogenous variable (X) to an endogenous variable (Y) could be understood as a vector transfer; a vector process. That when these transfers lead to mediation or suppression, they did not take place to achieve mediation or suppression rather, that mediation or suppression are consequences of those transfers. Thus, we may not use the regression coefficients under suppression to deny that a transfer took place or, to label one as spurious. When the transfers are imagined as vector processes, mediation or reverse mediation may be understood as processes within a system reaching for equilibrium. Hence, the process starts and then

stops rather than going on forever. For this reason, this dissertation argued that reverse mediation is possible for the same reason(s) that mediation is possible; that suppression can be theoretically understood and explained as a reverse mediation. This dissertation further argued that both mediation and reverse mediation could be explained through theory. Any attempt to explain reverse mediation (suppression) using the results of empirical studies (regression coefficients) may likely yield more definitions for suppressor variables and also, more identification of different suppressor variables (Gaylord-Harden, et al., 2010; Jose, 2013).

6.9. Research conclusions

The motivation variables identified in this dissertation are: personal relevance of learning mathematics, students' academic interest, students' academic achievement goal, hope, pride, and the importance of mathematics to the future career goals of each student.

The academic mediator variables identified in this dissertation are intrinsic and extrinsic motivation. The academic moderator variables identified in this dissertation are mathematics self-efficacy belief, self-determination, and anxiety about mathematics assessment.

This dissertation grouped academic achievement variables into three categories: motivator, mediator and moderator variables. This grouping is required because the different categories play different roles in a student's academic achievement and thus in accounting for observed differences amongst students, e.g., possible gender effect, differences in academic ability, academic preparation, and also the effect of treatments like different teaching and motivation strategies.

Following Hayes (2013), this dissertation proposed a moderated mediation model as the appropriate theoretical framework for investigating the relationship between motivation and academic achievement. This framework expands the range of analysis that we could use to investigate the relationship between motivation and academic achievement.

We do not know in advance which of intrinsic or extrinsic motivation variables that a student might use to engage an academic activity. What we do know is that a student may not use both simultaneously for the same activity. Thus, collecting data for both variables from research participants for the same activity is not consistent with the definition of these variables. If we do, we may not know which of the two variables that a student used to engage the activity.

Bandura (2001) argued that outcomes are consequences of agentic acts, rather than a property of those acts. That sometimes agentic acts, however well intended, may yield unexpected outcomes. It is part of our lived experience that sometimes students who were less prepared might achieve better academic outcomes than students who were better prepared for the same examination. It is also possible that two students who were equally prepared for the same examination might achieve different outcomes. Thus, while in general students who were better prepared may achieve better academic outcomes in the long run; it is not the case that we can reach that conclusion using the result of a single event, a single experiment as suggested by this research framework. Also, it seems unlikely that motivation has a proportional relationship with academic achievement measured through a student's grade in an assigned course. For this reason, this dissertation argued that a superior difference in academic achievement might not be a strong basis for inferring a superior difference in motivation amongst individual students. Thus, this dissertation concludes that with respect to individual students, the expected inferences promised by this research framework may not be theoretically justified.

This research framework is more suited for comparing groups of students like different classrooms, or groups of students subjected to different treatments, or for investigating the impact of treatments in different classroom settings. For example, this research framework may be used to investigate the impact of gender, differences in levels of mathematics anxiety, or self-efficacy belief amongst students, etc. For these group studies, we could invoke the central limit theorem as a theoretical justification for the application of this research framework. For example, we may argue that the average result for each group is an estimate of its population value for that group. Thus different group values are different estimates of their population value and thus, statistically equal within a 95% confidence interval.

The results of my mediation analysis using intrinsic or extrinsic motivation show direct effects that were each greater than the total effect. However, the result for intrinsic motivation was not statistically different from zero, while that for extrinsic motivation was statistically different from zero. If intrinsic and extrinsic motivations are different ways of engaging an academic activity, and each of them facilitates academic achievement, then we should expect a direct effect that is greater than the total effect. More work would be required to fully understand this process.

The results of my moderated mediation analysis were not statistically significant. The lack of significance of these results might be due to a lack of significant correlation between the explanatory variables and academic achievement (grades) that was observed for this study. However, using theoretical arguments, one expects that different levels of mathematics self-efficacy belief might have an effect on the relationship between a student's motivation and her academic achievement (Pajares & Miller, 1994; Beghetto & Baxter, 2012)

The results of my multiple regression analysis (study 1) were unexpected. However, the lack of an apparent trend in the residual plots suggests that, the observed results might be connected to the poor correlation statistics between the explanatory variables and student's academic achievement variables that was observed in this study.

On the relationship between self-efficacy belief, persistence, and motivation, this dissertation concludes that given motivation, one can infer persistence and through persistence, effort. That, persistence and effort might be reflective indicators of motivation.

6.10. Limitations of research framework

A limitation of this research framework is the difficulty with data collection. Because of privacy issues, one is required to have the permission of research participants and many others, sometimes parents and school administrators prior to collecting research data. This limits the pool of research participants. Also, the large number of variables required to conduct this research may hinder participation because of the time required for participants to complete the research survey.

6.11. Closing thoughts

An issue that appears to be missing from the many discussions in the research literature is a possible separation between how one might prepare for an examination compared to how the same person might acquire the same knowledge for long-term use. The question is whether there might be a difference in how students acquire knowledge for short term use (prepare for examinations) and how they may acquire the same knowledge for long term use (career goals). Since the time frames are different, one suspects that there might be differences in strategies with respect to maximizing each outcome. The research literature appears to treat the two as the same as this dissertation noticed no such distinction in the research literature. For example, cramming for an examination that will take place the next day does not by itself suggest that one believes that cramming is the best way or even a good way to acquire knowledge for long term use. As a student, I am inclined to believe that many students see the two as different, and treat them as such. It appears that the research literature makes no such distinction. The suggestion that we may use how one prepares for an examination to infer her preferences with regards to that activity ignores the power of incentives, and one's reason for engaging in an activity. We will be less than human if we fail to take advantage of the incentives before us as we prepare for events.

These questions are important because if knowledge acquired for a given purpose served its purpose, then unless one can show that the same knowledge could have been acquired with less resources, e.g. in less time using a different method of learning, any claim of one method of learning being better than the one used, would be a weak argument. Time is an important resource and the different methods of acquiring knowledge may require different time resources.

6.12. Future studies

An important theme of this research and a major challenge of the research on motivation and academic achievement is the question of how to motivate our students.

How do we persuade our students to do what we want them to do or what we believe is good for them?

Many students, especially male students' dream of being basketball, hockey, soccer players, etc., those, that do, by all indications, work hard at achieving their goals through keeping regular practice hours. Thus, it cannot be said that many male students are lacking in focus, or lacking in commitment or motivation. Other students who dream of being doctors, lawyers, and teachers, etc., appear to do well in school on their own, especially many female students. The problem appears to be that in many societies, many male students do not have such dreams. To motivate them, it might be helpful to find ways to make them want something, value something and desire something; make them want to be somebody much like many of them want to be a basketball player or a doctor, etc.

The claim here is that when people want things for themselves, they tend to find ways to motivate themselves and do the necessary things to achieve their goal. These include displaying the characteristics of motivated people. For this reason, an important contribution of this dissertation might be that the proposed research framework could be helpful in investigating the effect of treatments on students' motivation for academic achievement. Through a trial and error process, we could determine what works or does not work, make the necessary changes as we seek the best way for motivating our students.

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Appendix A

SFU Informed Consent Document

INFORMED CONSENT

I am inviting you to participate in my research on The Relationship between motivation, achievement goals, achievement variables and mathematics achievement. I am conducting this research to fulfill the thesis requirements of a PhD degree in Mathematics Education.

Although there are no immediate benefits to you as a participant, the principle goal of this study may be of benefit to future students and hopefully to you as you continue your studies. Research reports show that motivation variables, achievement goals, and achievement variables all contribute in some way to academic achievement; however, the specific contribution and/or the role of each of these variables in academic achievement are still not clear. A principal aim of this study is to identify the specific role that each of the above variables plays in academic achievement and subsequently classify them either as causal variables, moderators and/or mediators of academic achievement and through this, hopefully shed some light on a vexing question namely: *what are the causal variables of academic achievement?*

I ask for your participation because essentially, this study is about students; it is about you and why you are here, studying instead of being elsewhere and doing something else. Your responses to the survey questions used in conjunction with your grades in your mathematics course are the data requirements for this study. Previous studies on this issue have used primary and secondary school students. This will be the first of such study to focus on university students, and I suspect that the differences in knowledge and maturity of university students compared to primary and secondary school students may produce different outcomes compared to those of previous studies. If you do volunteer to participate in this study, you may complete this survey questionnaire online at any time of your convenience within a one week period, and the process may take about 30 minutes to complete. You would be required to:

1. Read and accept the conditions stipulated on this Informed Consent page by checking the “I agree to these terms and conditions” marker, and then selecting the “Next” button. The next page would ask for your student registration number, gender, and major/field of study.

2 The third and subsequent pages would ask that you respond to 51 questions centering on your academic motivation, your academic interests, career goals, achievement goals, achievement emotions, and perceived importance of mathematics to your future career goals.

3. I would use your registration number to ask your course Instructor for your grade in this course. This is important because we want to investigate how differences in student’s responses to the survey questions might be related to differences in achievement outcomes. After entering the grades in research data file, your registration numbers would be deleted from all files and also, from the server by deleting the survey questionnaire from the server. Please note that your student registration number is NOT a required data for this study.

4. Please note that you may quit this survey at any time if you choose to no longer participate by selecting the “Discard responses and exit” button. Also, please note that your refusal to participate in this survey or your decision to withdraw at any time you choose will have no adverse effects on your grades or evaluation in this or any other course.

5 To promote student participation in this survey, I will conduct a raffle draw of 20 paid phone cards each worth about C$5.00 (about 600 Siri-Lanka Rupees). Here, winners of this draw will be randomly selected from all the students who had successfully completed the survey. Also, to ensure that every participant gets something, I am also proposing a gift of a fountain pen worth about C$1.00 (about 120 Rupees) to every student who participates in the survey.

If you have any questions, concerns or need more information, you may contact me using xxxxxxx@sfu.ca

I sincerely thank you for your participation.

Appendix B

Research Instruments

Research Questionnaire Instruments

Participants will respond to the following 51 questions on motivation, academic achievement goals, academic achievement emotions, academic interests, and, the importance of mathematics to their future career goals. The motivation construct has 6 components and 30 questions, academic achievement emotions, 2 components and 6 questions, academic interests, 7 questions, achievement goals, 7 questions and the importance of mathematics to their future career goals, 1 question. All questions would be answered on a 7 point Likert type scale showing level of agreement with each question e.g. (1 – Strongly disagree, 2 – Disagree, 3 – Somewhat disagree, 4 – Neither agree or disagree, 5 – Somewhat agree, 6 – Agree, 7 – Strongly agree). (Total number of component variables = 11; + students grade = 12 component variables)

Motivation

Intrinsically motivated mathematics learning

(i) I enjoy learning mathematics.

(ii) The mathematics I learn is more important to me than the grade I receive.

(iii) I find learning mathematics interesting.

(iv) I like mathematics that challenges me.

(v) Understanding mathematics gives me a sense of accomplishment.

Extrinsically motivated mathematics learning

(i) I like to do better than the other students on mathematics tests.

(ii) Earning a good mathematics grade is important to me.

(iii) I think about how learning mathematics can help me get a good job.

(iv) I think about how my mathematics grade will affect my overall grade point average.

(v) I think about how learning mathematics can help my career.

Personal relevance of learning mathematics

(i) The mathematics I learn relates to my personal goals.

(ii) I think about how the mathematics I learn will be helpful to me.

(iii) I think about how I will use the mathematics I learn.

(iv) The mathematics I learn is relevant to my life.

(v) The mathematics I learn has practical value for me.

Self-determination to learn mathematics

(i) If I am having trouble learning mathematics, I try to figure out why.

(ii) I put enough effort into learning mathematics.

(iii) I use strategies that ensure I learn mathematics well.

(iv) It is my fault, if I do not understand mathematics.

(v) I prepare well for mathematics tests and labs.

Self-efficacy for learning mathematics

(i) I expect to do as well as or better than other students in a mathematics course.

(ii) I am confident I will do well on mathematics labs and projects.

(iii) I believe I can master the knowledge and skills in a mathematics course.

(iv) I am confident I will do well on mathematics tests.

(v) I believe I can earn a grade of “A” in a mathematics course.

Anxiety about mathematics assessment (Reverse-scored items)

(i) I am nervous about how I will do on mathematics tests.

(ii) I become anxious when it is time to take a mathematics test.

(iii) I worry about failing mathematics tests.

(iv) I am concerned that the other students are better in mathematics.

(v) I hate taking mathematics tests.

Academic achievement emotions – Hope

(i) I am confident when I go to class.

(ii) I have an optimistic view toward studying

(iii) I have great hope that my abilities will be sufficient

Academic achievement emotions – Pride

(i) I am proud of myself

(ii) I am proud of my capacity

(iii) I am proud of how well I mastered the exam

Student's academic interest

(i) I've always been fascinated by mathematics

(ii) I choose to take mathematics because I' m really interested in the topic

(iii) I'm really excited about taking this class

(iv) I'm really looking forward to learning more about mathematics

(v) I think the field of mathematics is an important discipline

(vi) I think what we will study in mathematics will be important for me to know

(vii) I think what we will study in mathematics will be worthwhile to know

Student's academic achievement goals

(i) The most important thing for me in this course is to understand the content as thoroughly as possible.

(ii) Mastering the material in mathematics is important to me.

(iii) I want to learn as much as possible in this class.

(iv) I like it best when something when I learn in this course makes me want to find out more.

(v) In a class like this, I prefer course material that really challenges me so I can learn new things.

(vi) My goal in this class is to learn as much as I can about this topic.

(vii) In a class like this, I prefer course material that arouses my curiosity even if it is difficult to learn.

The importance of mathematics to future career goals.

Here, students would state their perception of the importance of mathematics to their future career goals using a 7 point Likert-type scale as follows:

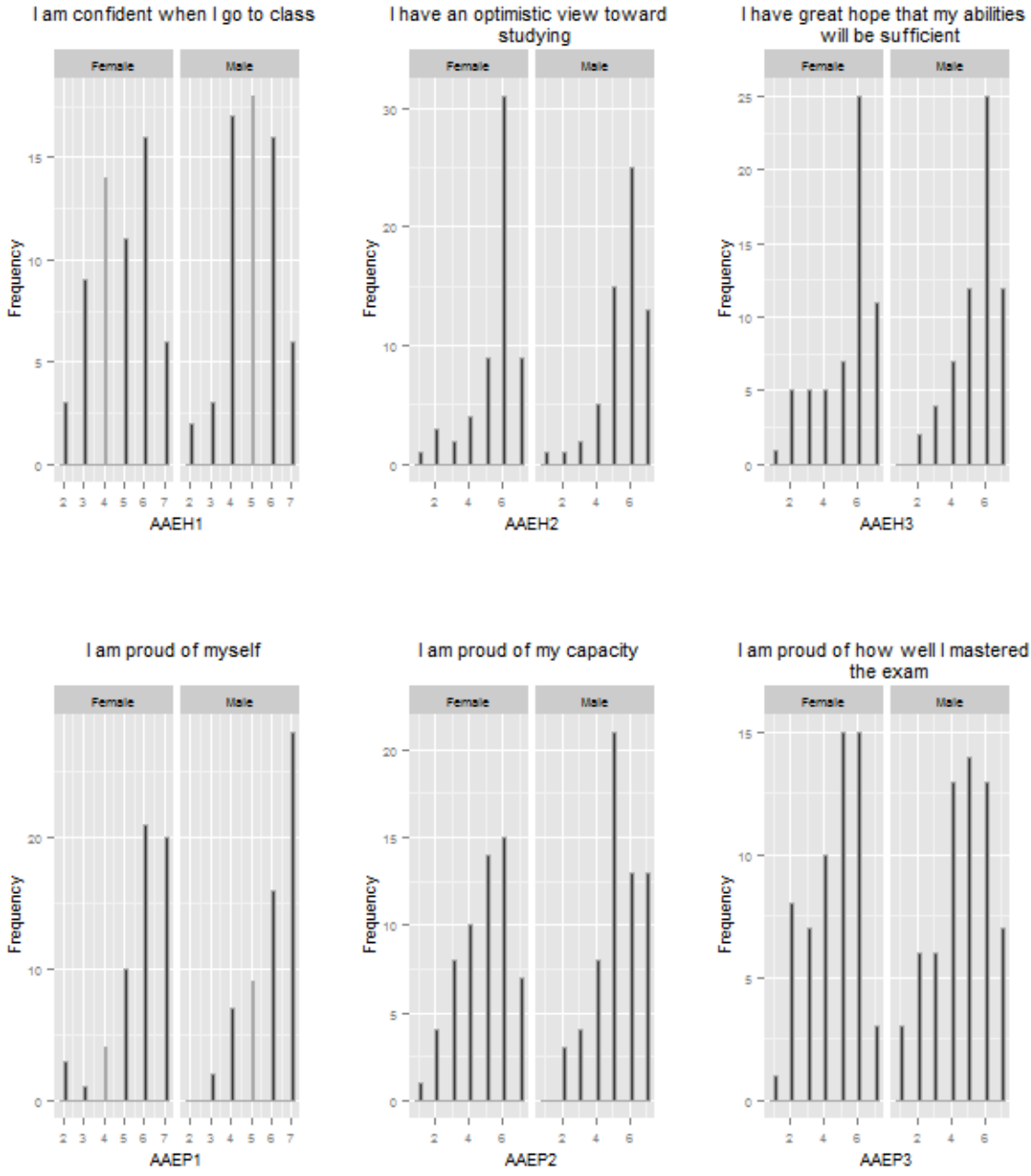
(1 – Not at all important, 2 – Low importance, 3 – Slightly important, 4 – Neutral, 5 – Moderately important, 6 – Very important, 7 – Extremely important)

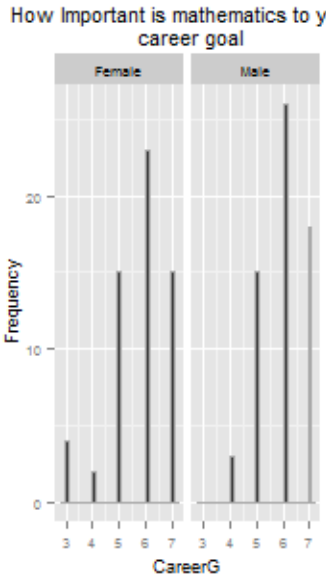
Student's mathematics achievement (student's grade in an assigned mathematics course)

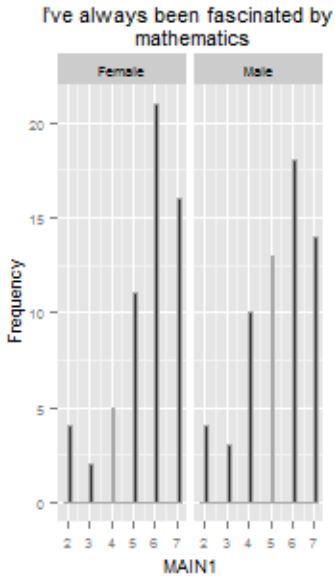
This data would be provided by the course Instructor.

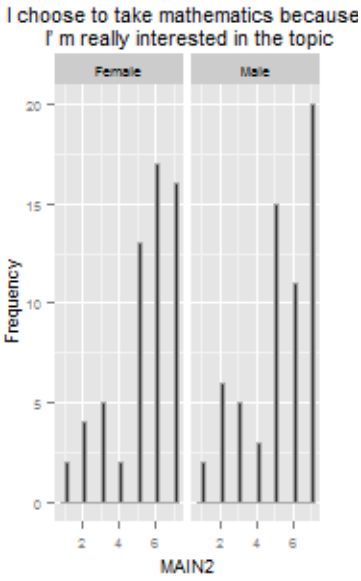
Appendix C

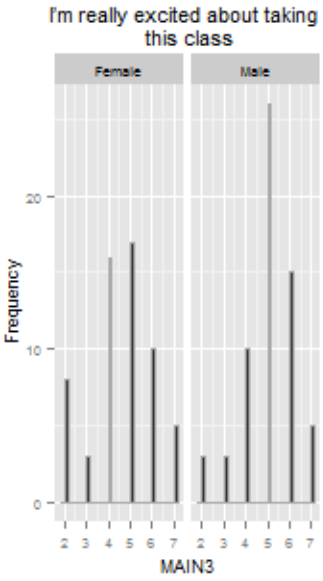
A visualization of student's responses on scale variables

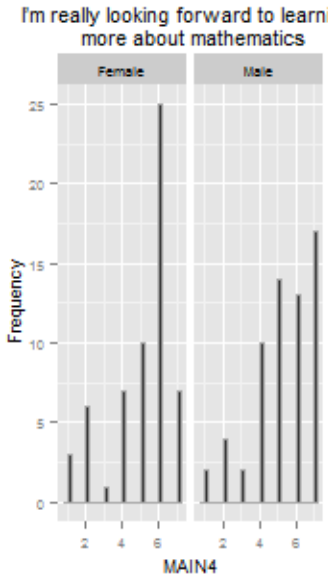


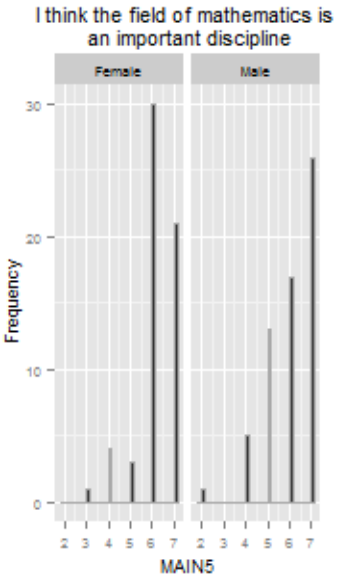

How Important is mathematics to your career goal
Female
Male
Frequency
CareerG

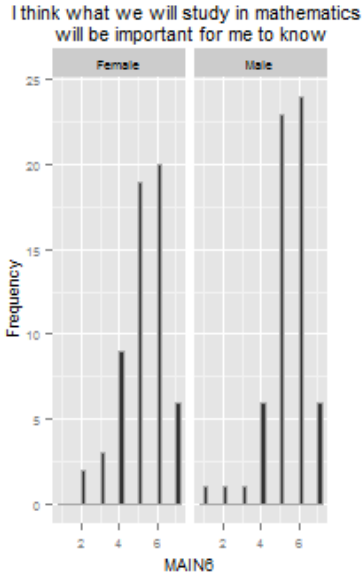

I've always been fascinated by mathematics
Female
Male
Frequency
MAIN1

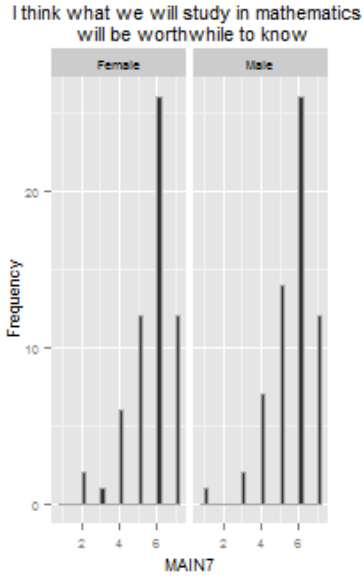

I choose to take mathematics because I' m really interested in the topic
Female
Male
Frequency
MAIN2

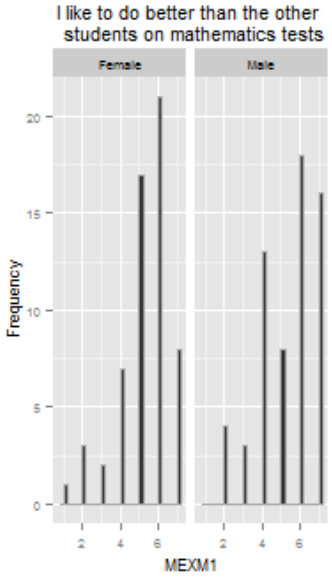

I'm really excited about taking this class
Female
Male
Frequency
MAIN3

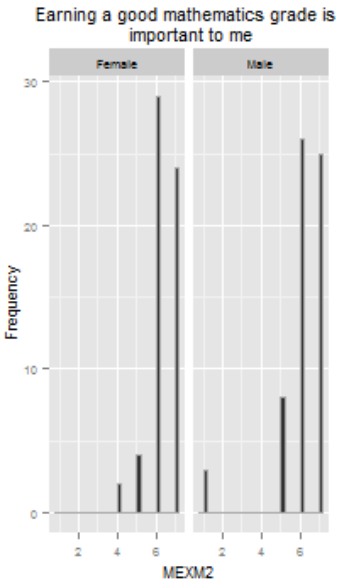

I'm really looking forward to learning more about mathematics
Female
Male
Frequency
MAIN4

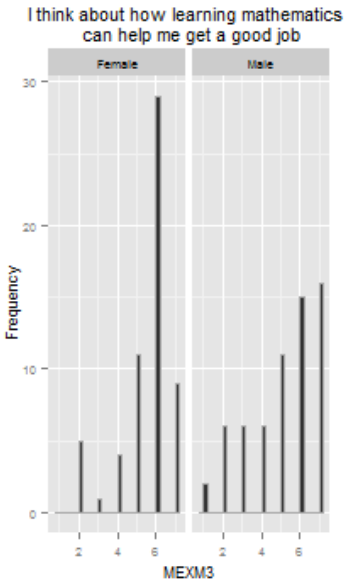

I think the field of mathematics is an important discipline
Female
Male
Frequency
MAIN5

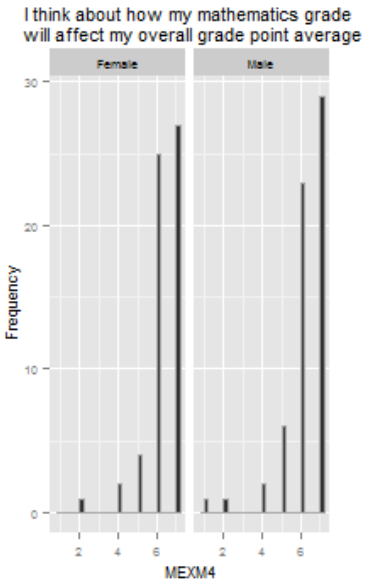

I think what we will study in mathematics will be important for me to know
Female
Male
Frequency
MAIN6

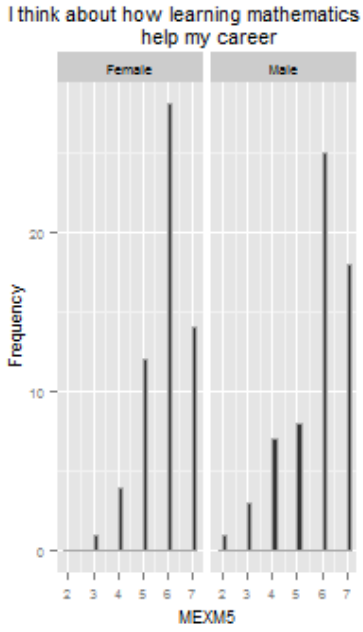

I think what we will study in mathematics will be worthwhile to know
Female
Male
Frequency
MAIN7

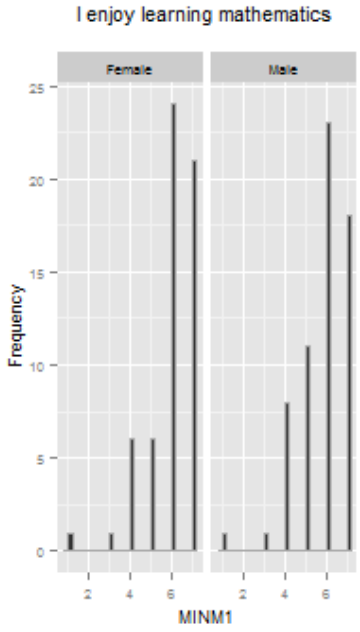

I like to do better than the other students on mathematics tests
Female
Male
Frequency
MEXM1

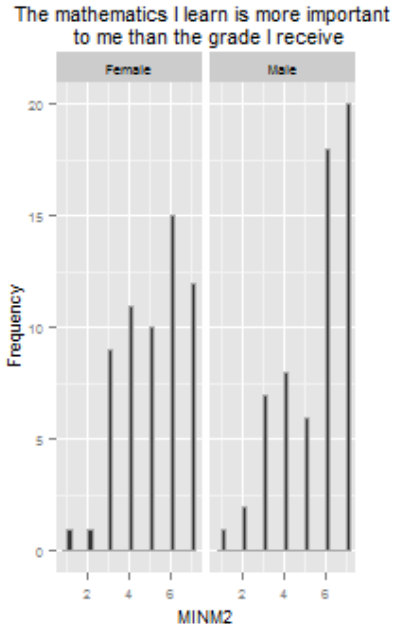

Earning a good mathematics grade is important to me
Female
Male
Frequency
MEXM2

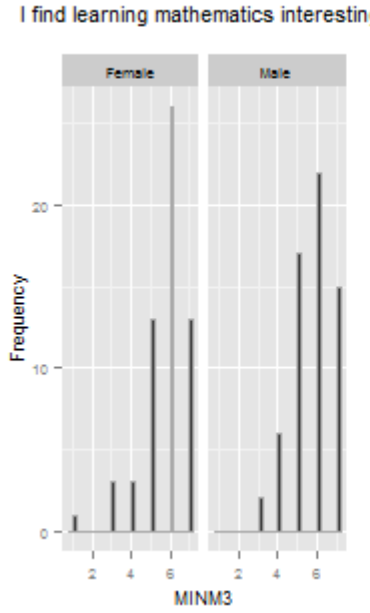

I think about how learning mathematics can help me get a good job
Female
Male
Frequency
MEXM3

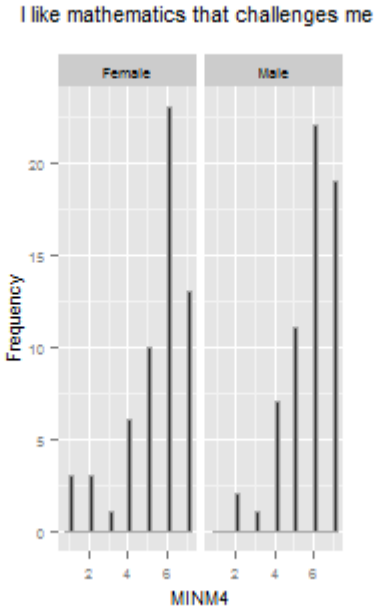

I think about how my mathematics grade will affect my overall grade point average
Female
Male
Frequency
MEXM4

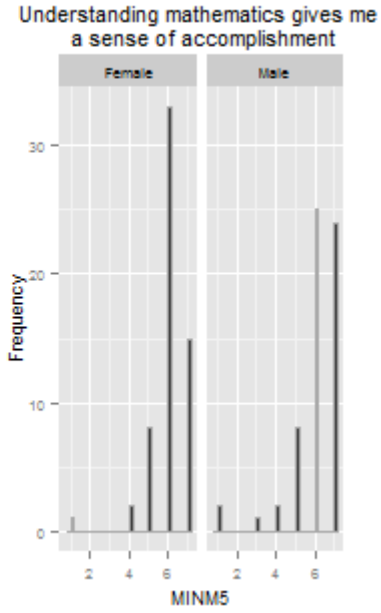

I think about how learning mathematics cai
help my career
Female
Male
Frequency
MEXM5

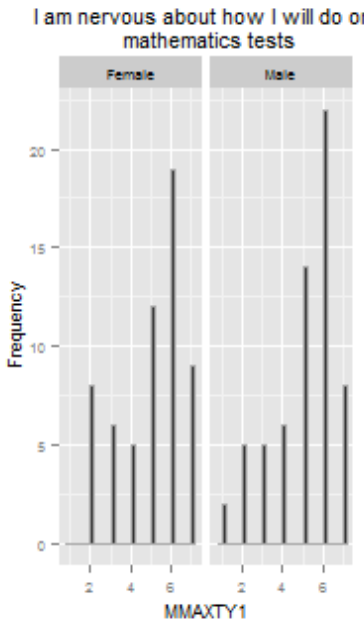

I enjoy learning mathematics
Female
Male
Frequency
MINM1

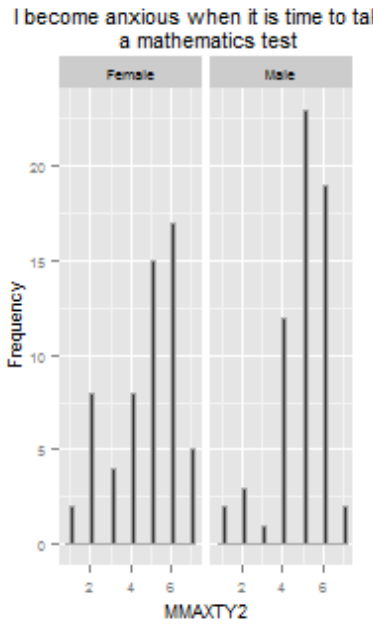

The mathematics I learn is more important
to me than the grade I receive
Female
Male
Frequency
MINM2

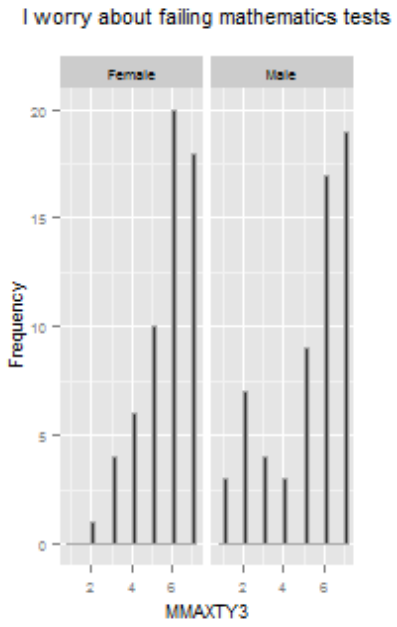

I find learning mathematics interesting
Female
Male
Frequency
MINM3

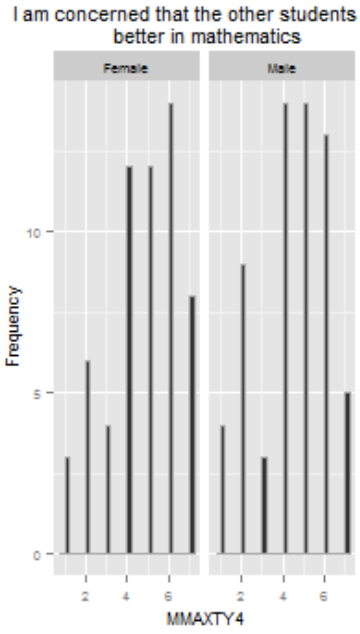

I like mathematics that challenges me
Female
Male
Frequency
MINM4

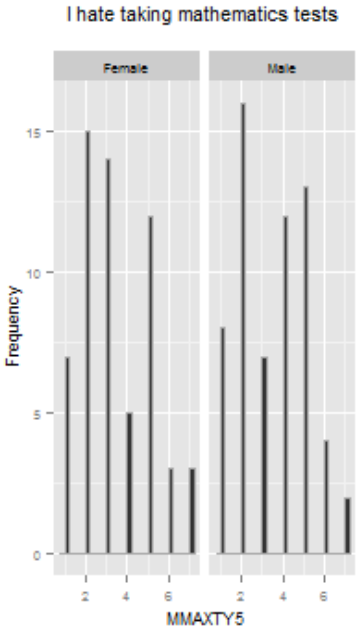

Understanding mathematics gives me
a sense of accomplishment
Female
Male
Frequency
MINM5

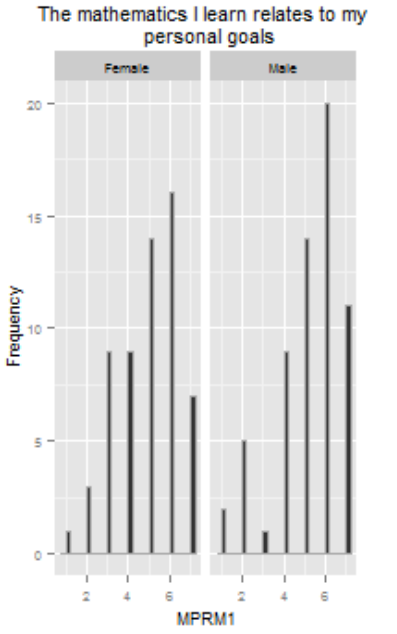

I am nervous about how I will do on mathematics tests
Female
Male
Frequency
MMAXTY1

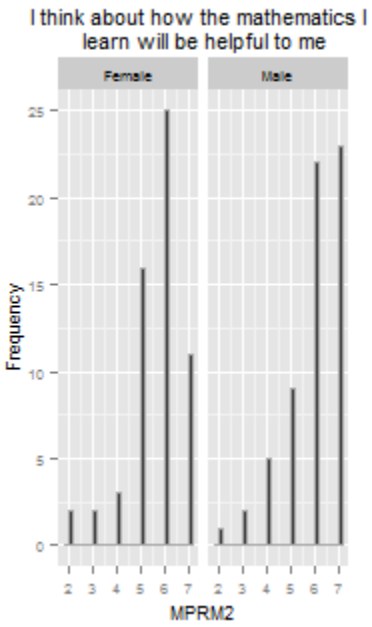

I become anxious when it is time to take a mathematics test
Female
Male
Frequency
MMAXTY2

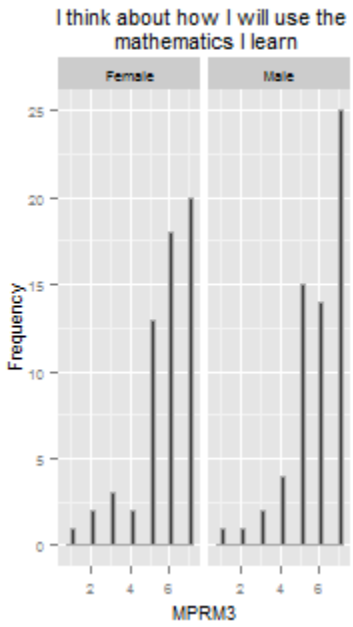

I worry about failing mathematics tests
Female
Male
Frequency
MMAXTY3

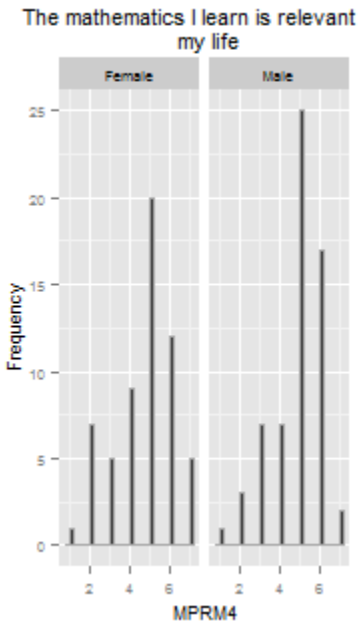

I am concerned that the other students are better in mathematics
Female
Male
Frequency
MMAXTY4

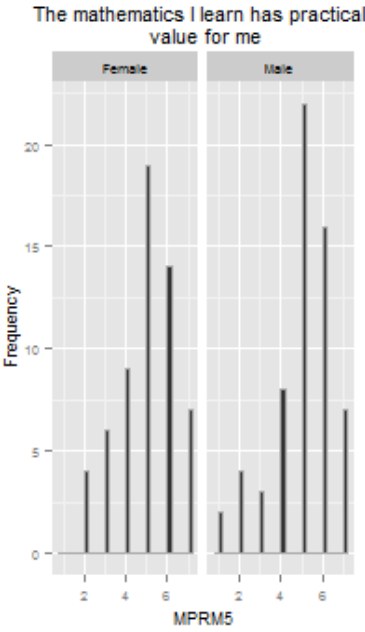

I hate taking mathematics tests
Female
Male
Frequency
MMAXTY5

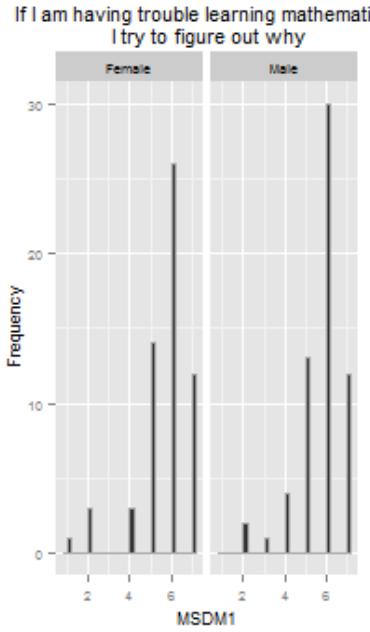

The mathematics I learn relates to my personal goals
Female
Male
Frequency
MPRM1

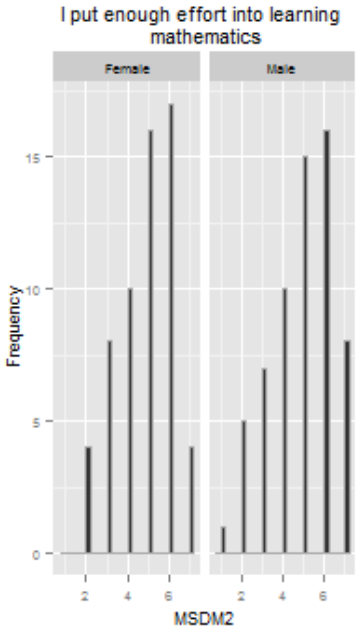

I think about how the mathematics I learn will be helpful to me
Female
Male
Frequency
MPRM2

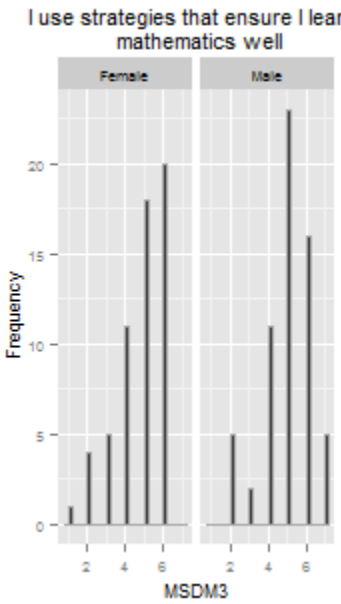

I think about how I will use the mathematics I learn
Female
Male
Frequency
MPRM3

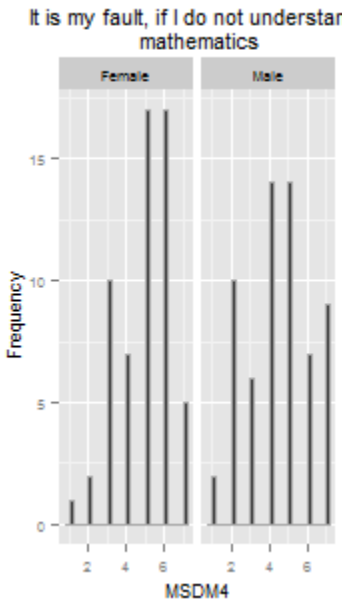

The mathematics I learn is relevant to my life
Female
Male
Frequency
MPRM4

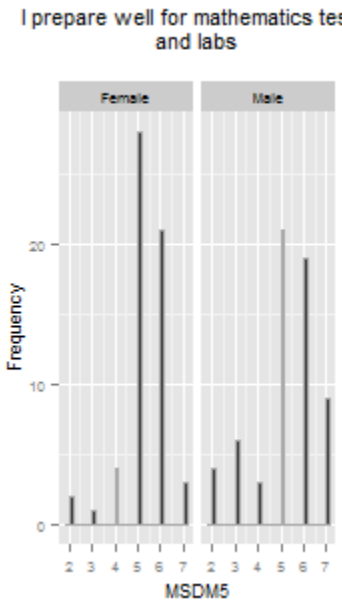

The mathematics I learn has practical value for me
Female
Male
Frequency
MPRM5

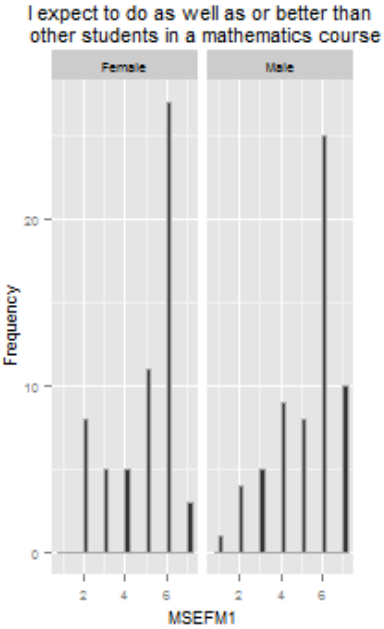

If I am having trouble learning mathematics I try to figure out why
Female
Male
Frequency
MSDM1

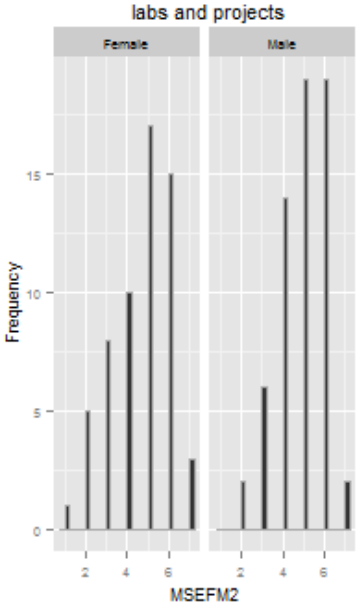

I put enough effort into learning mathematics
Female
Male
Frequency
MSDM2

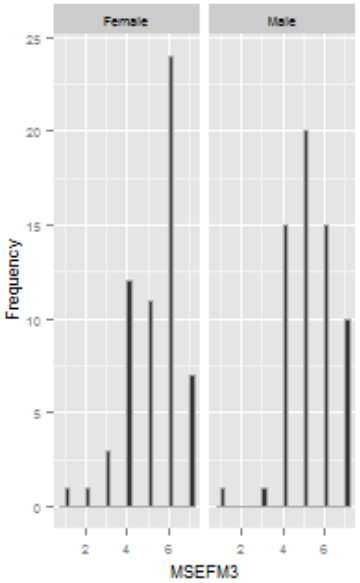

I use strategies that ensure I learn mathematics well
Female
Male
Frequency
MSDM3


It is my fault, if I do not understand mathematics
Female
Male
Frequency
MSDM4

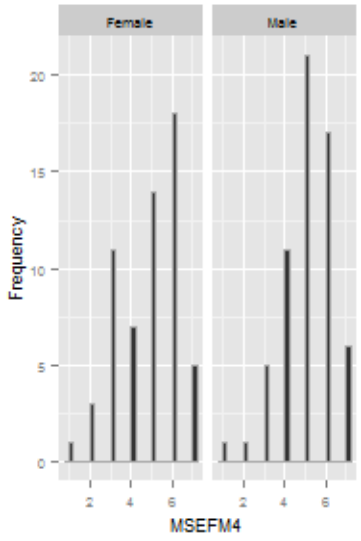

I prepare well for mathematics tests and labs
Female
Male
Frequency
MSDM5


I expect to do as well as or better than other students in a mathematics course
Female
Male
Frequency
MSEFM1

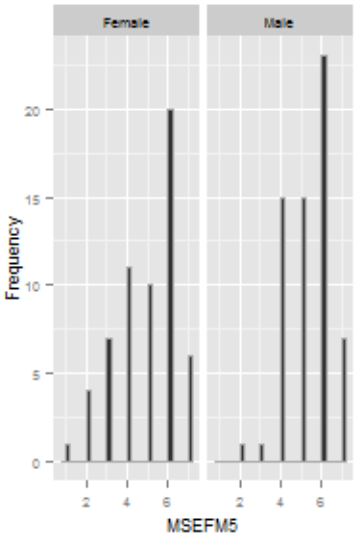

I am confident I will do well on mathematics labs and projects
Female
Male
Frequency
MSEFM2


I believe I can master the knowledge and skills in a mathematics course
Female
Male
Frequency
MSEFM3

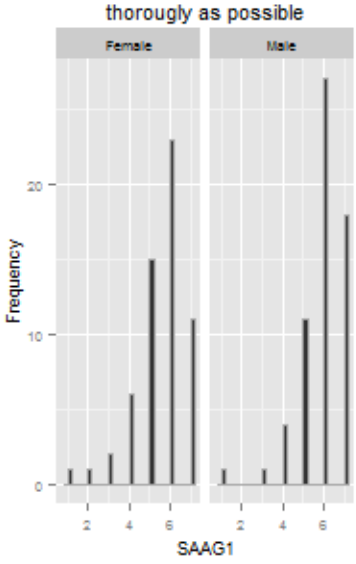
I am confident I will do well on mathematics tests



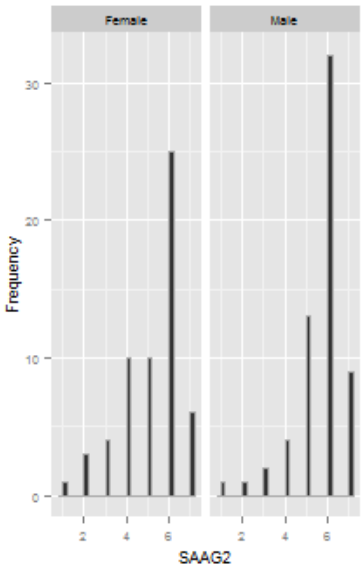
I believe I can earn a grade of "A" in a mathematics course



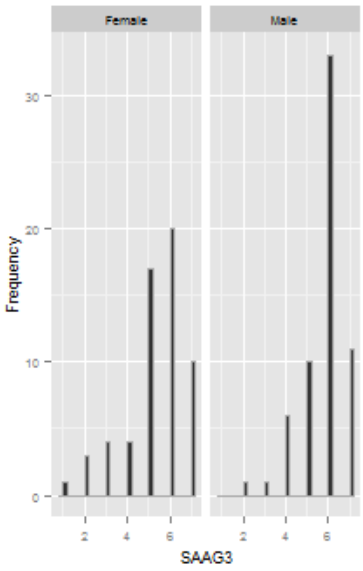
The most important thing for me in this course is to understand the content as thorougly as possible



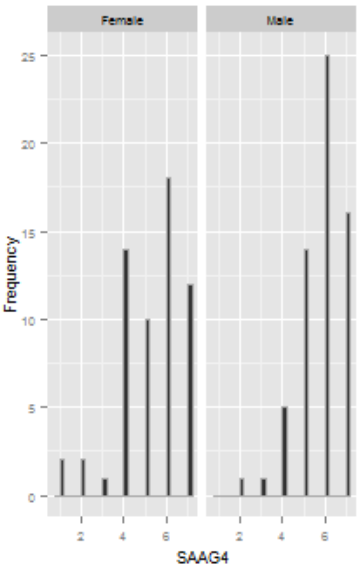
Mastering the material in mathematics is important to me

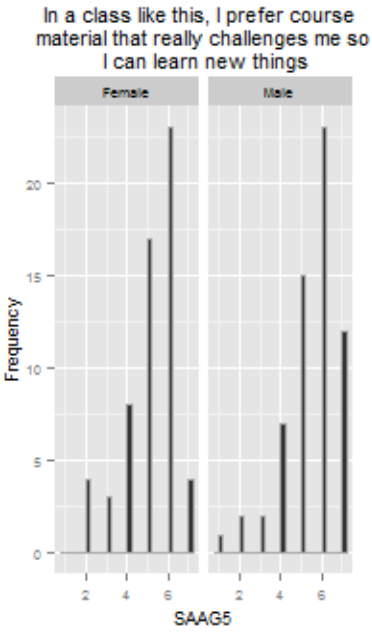


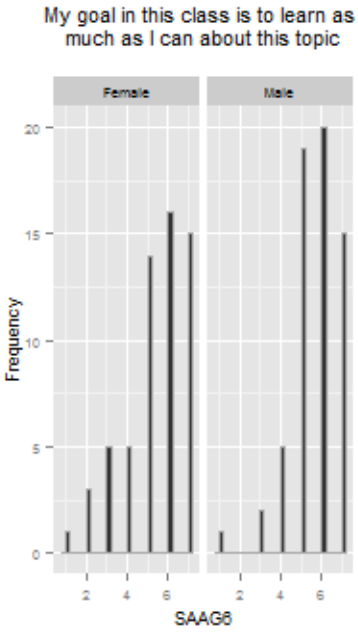
I want to learn as much as possible in this class

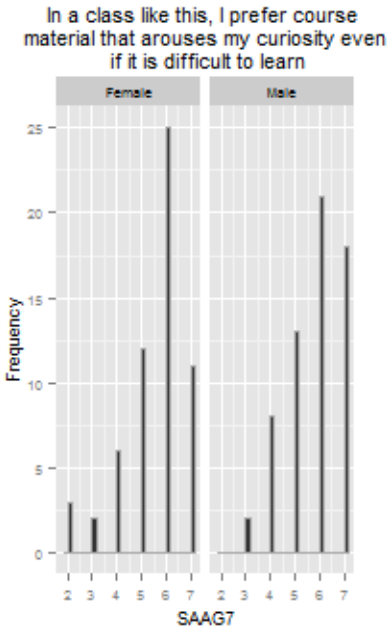


I like it best when something I learn in this course makes me want to find out more

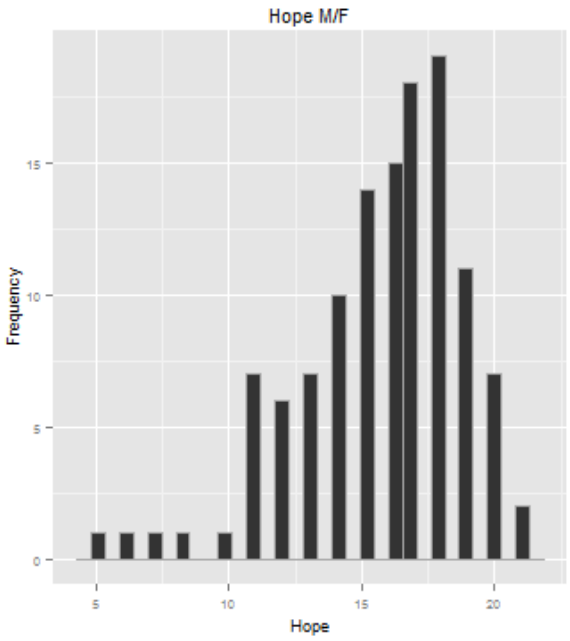


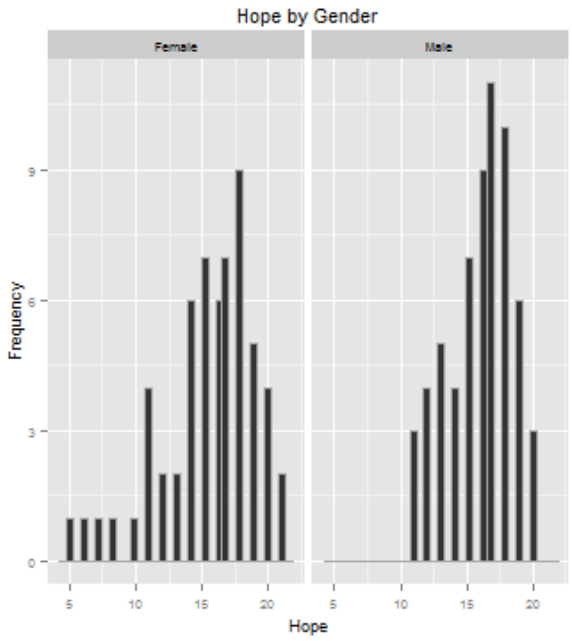

In a class like this, I prefer course material that really challenges me so I can learn new things
Female
Male
Frequency
SAAG5

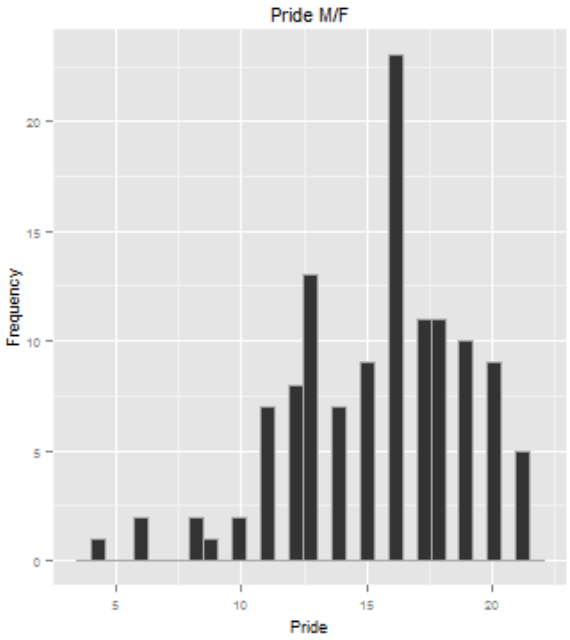

My goal in this class is to learn as much as I can about this topic
Female
Male
Frequency
SAAG6

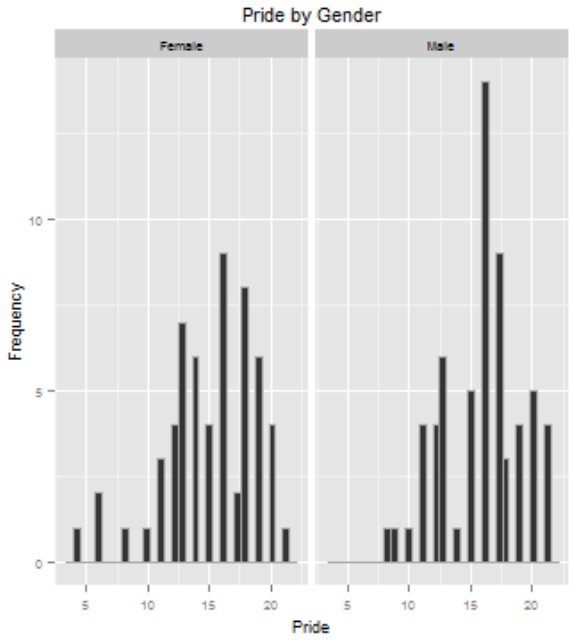

In a class like this, I prefer course material that arouses my curiosity even if it is difficult to learn
Female
Male
Frequency
SAAG7

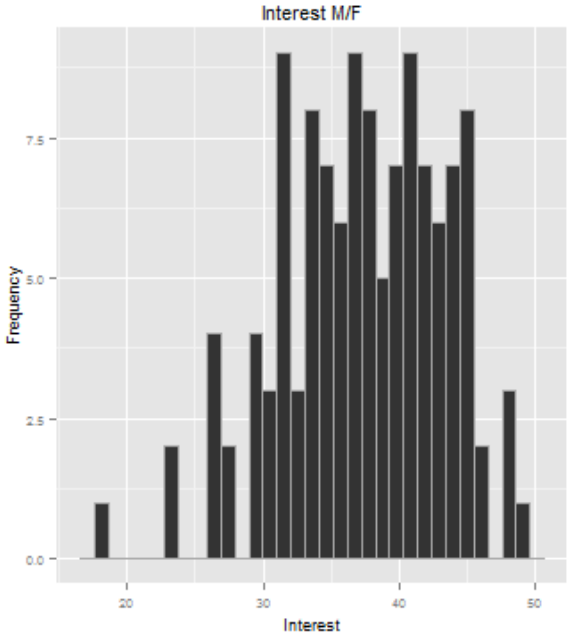
A visualization of the explanatory variables

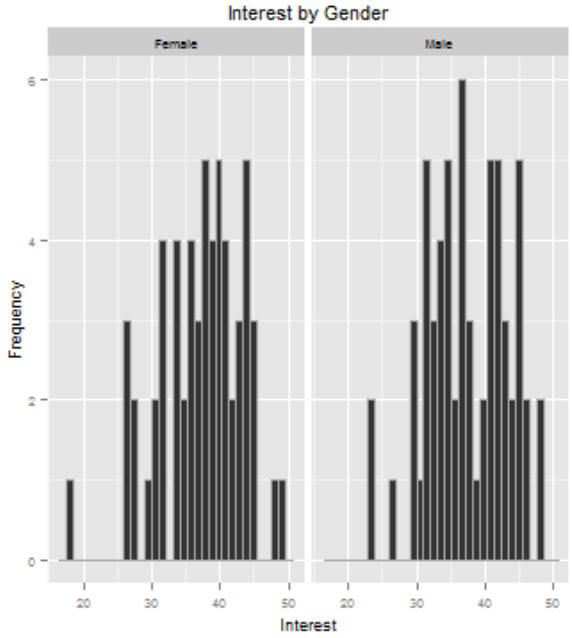


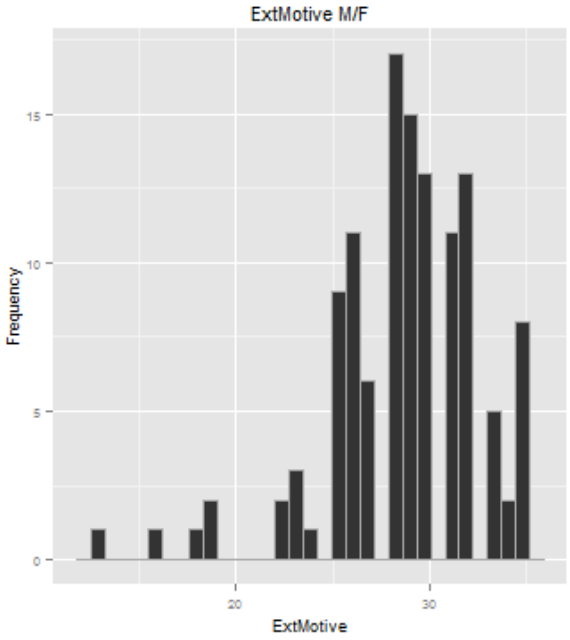


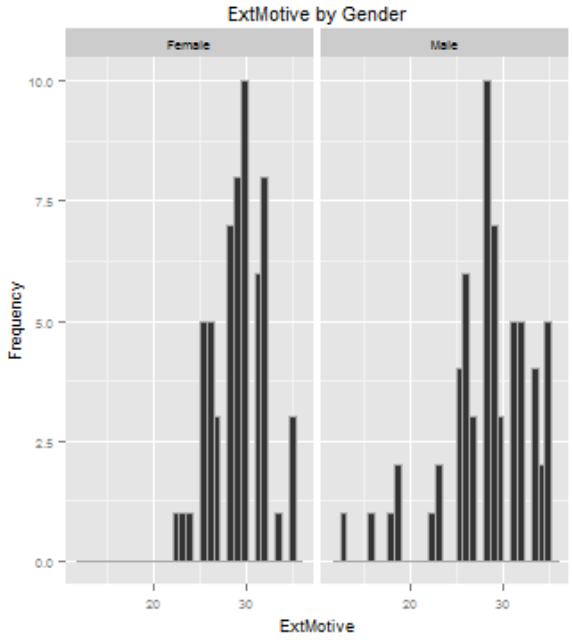


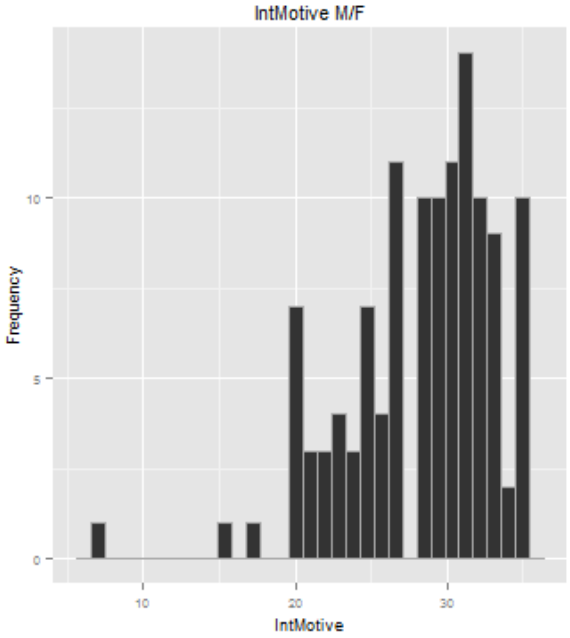


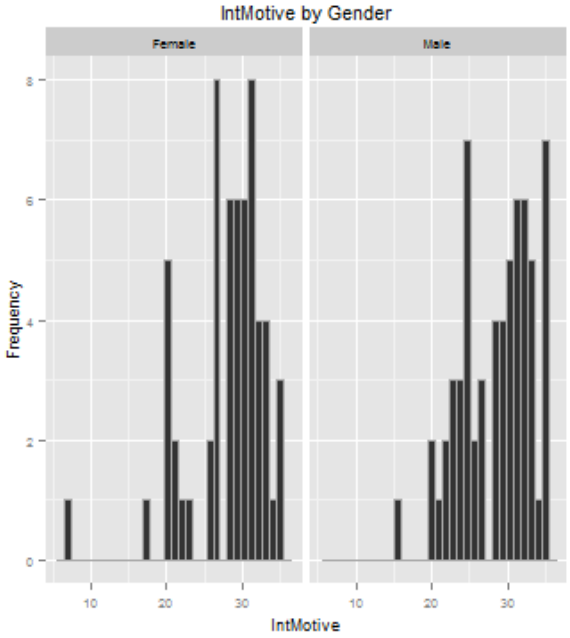

Interest M/F
Frequency
Interest
0.0
2.5
5.0
7.5
20
30
40
50

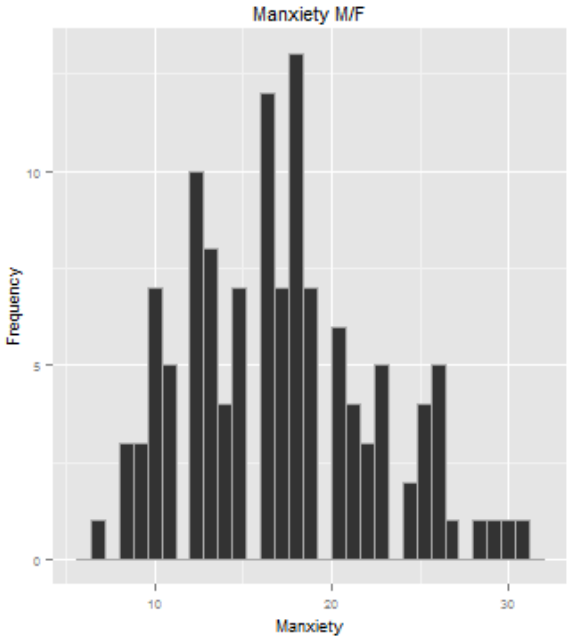

Interest by Gender
Female
Male
Frequency
Interest
0
2
4
6
20
30
40
50

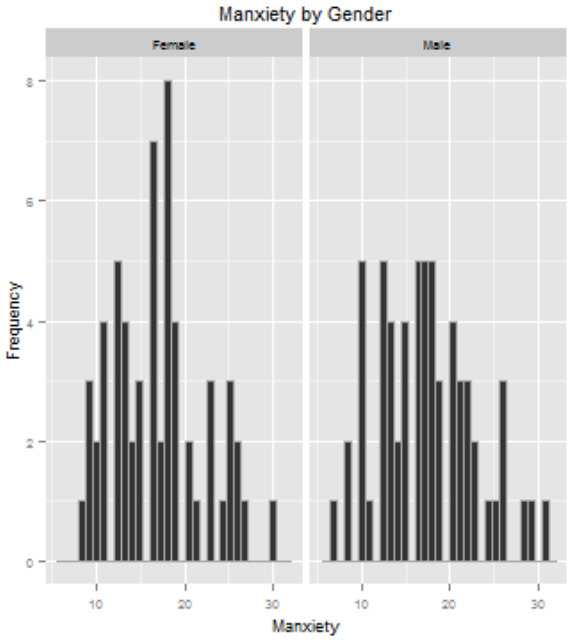

ExtMotive M/F
Frequency
ExtMotive
0
5
10
15
20
30

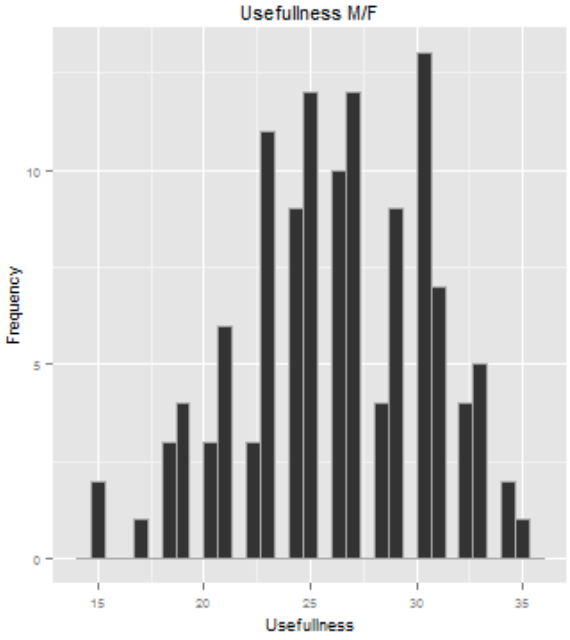

ExtMotive by Gender
Female
Male
Frequency
ExtMotive
0.0
2.5
5.0
7.5
10.0
20
30

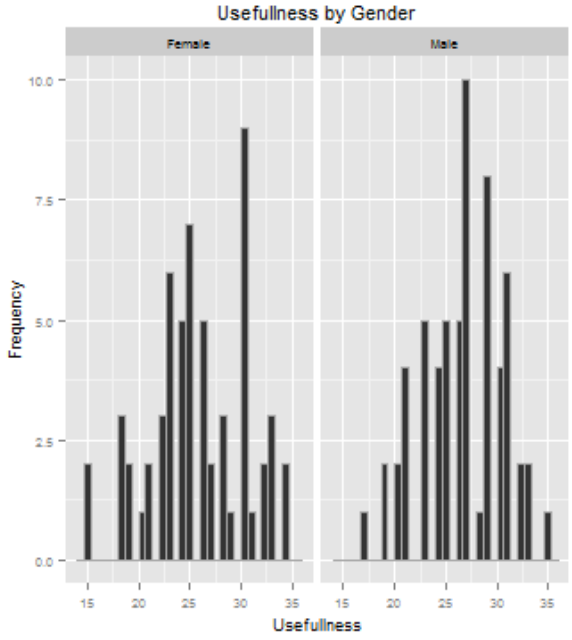

IntMotive M/F
Frequency
IntMotive
0
5
10
10
20
30

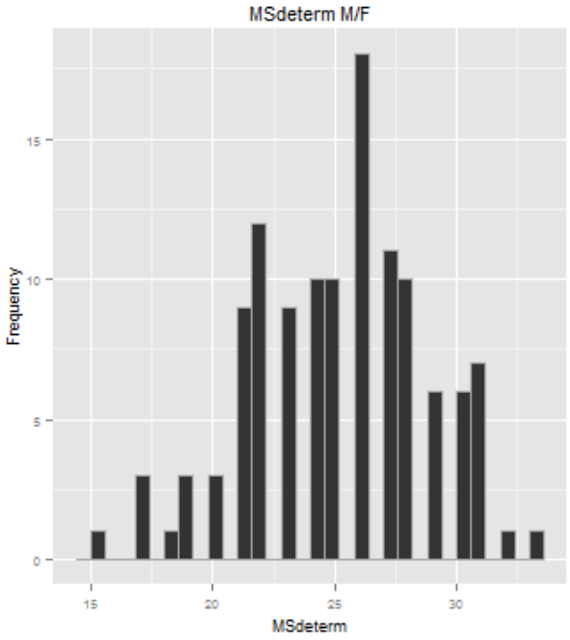

IntMotive by Gender
Female
Male
Frequency
IntMotive
0
2
4
6
8
10
20
30

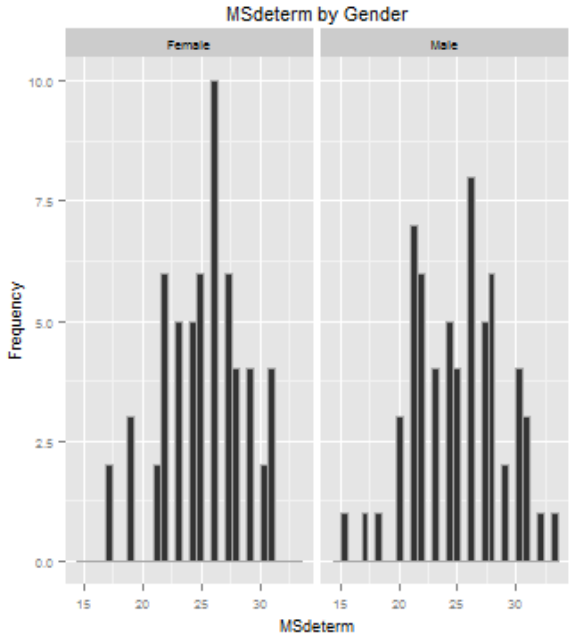

Manxiety M/F
Frequency
Manxiety
0
5
10
10
20
30

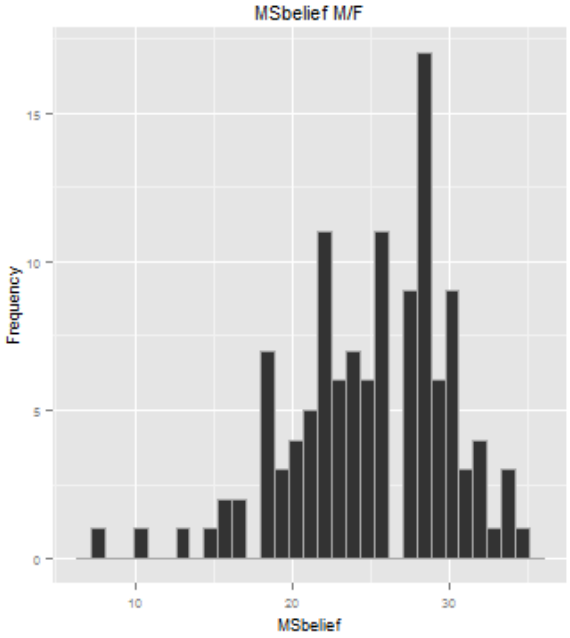

Manxiety by Gender
Female
Male
Frequency
Manxiety
0
2
4
6
8
10
20
30

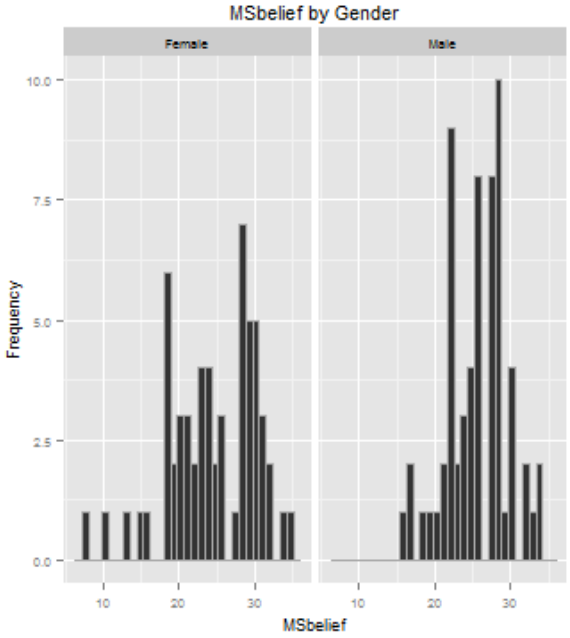

Usefullness M/F
Frequency
Usefullness
0
5
10
15
20
25
30
35

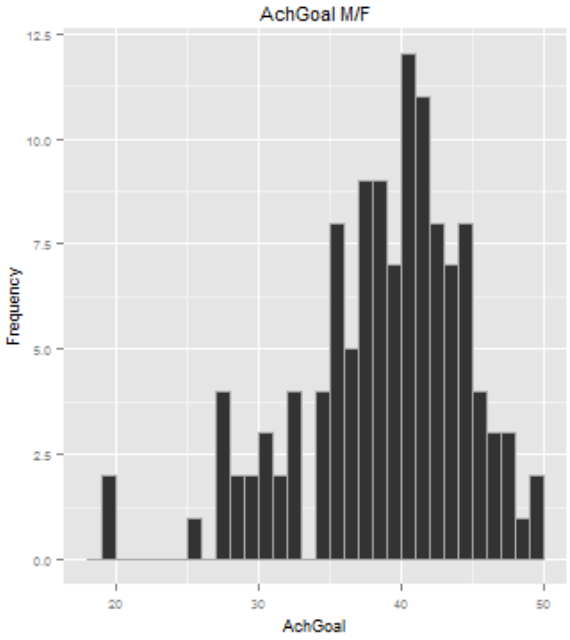

Usefullness by Gender
Female
Male
Frequency
Usefullness
0.0
2.5
5.0
7.5
10.0
15
20
25
30
35

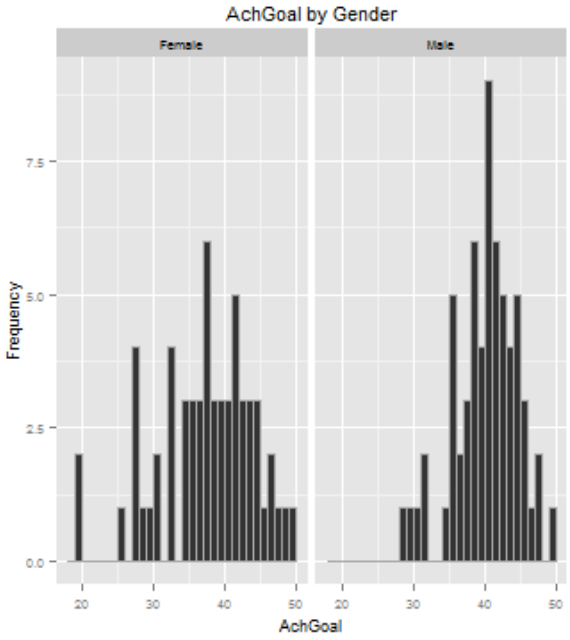

MSdeterm M/F
Frequency
MSdeterm
0
5
10
15
20
25
30

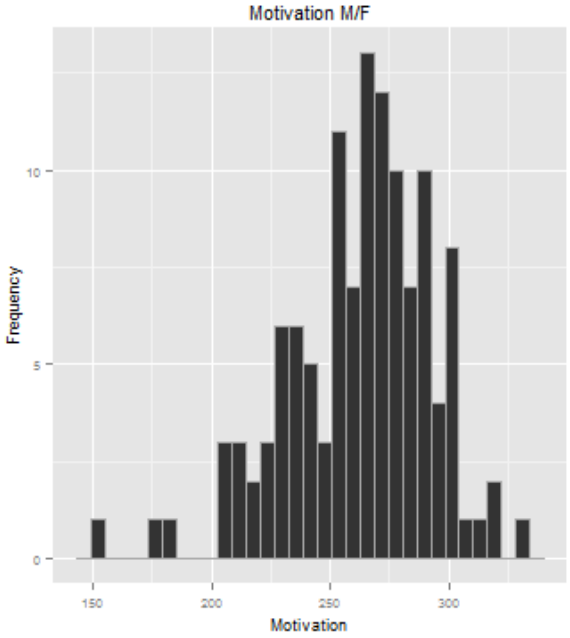

MSdeterm by Gender
Female
Male
Frequency
MSdeterm
0.0
2.5
5.0
7.5
10.0
15
20
25
30

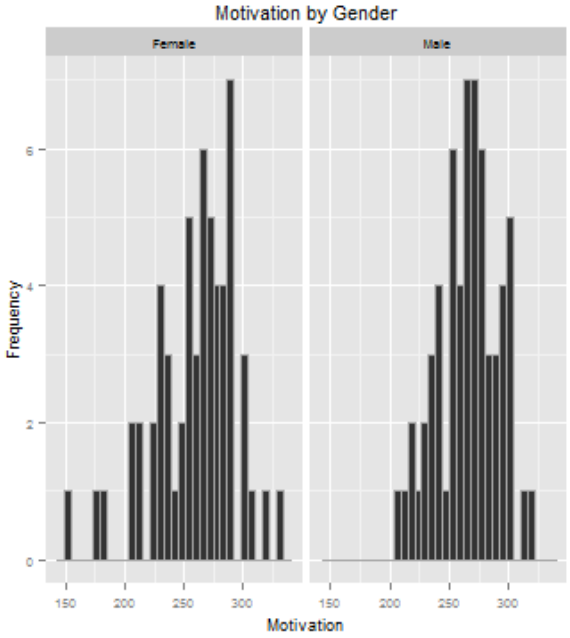

MSbelief M/F
Frequency
MSbelief
0
5
10
15
10
20
30

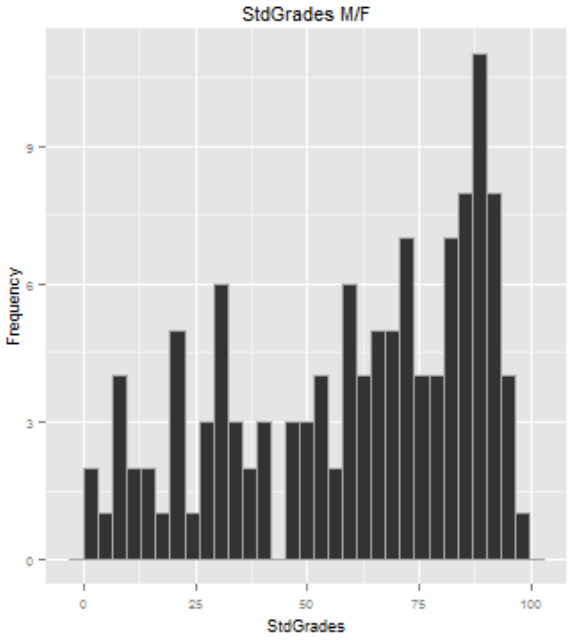

MSbelief by Gender
Female
Male
Frequency
MSbelief
0.0
2.5
5.0
7.5
10.0
10
20
30

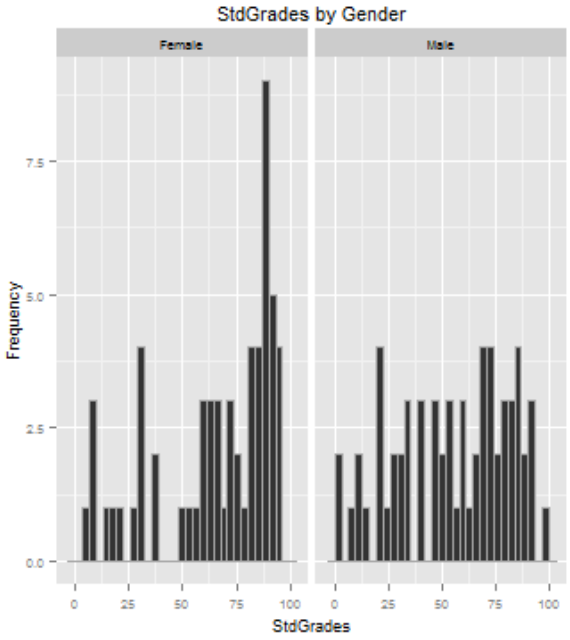

AchGoal M/F
Frequency
AchGoal
0.0
2.5
5.0
7.5
10.0
12.5
20
30
40
50

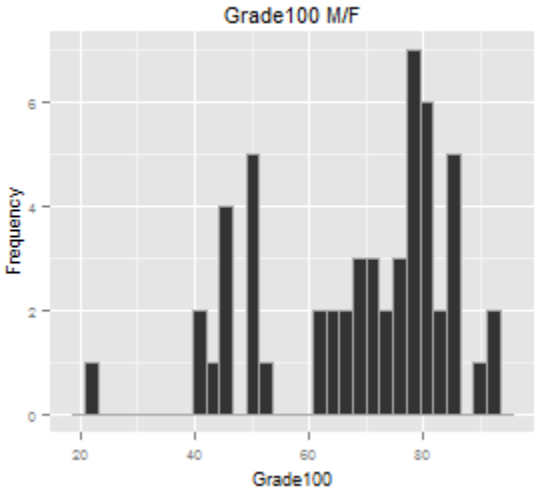

AchGoal by Gender
Female
Male
Frequency
AchGoal
0.0
2.5
5.0
7.5
20
30
40
50

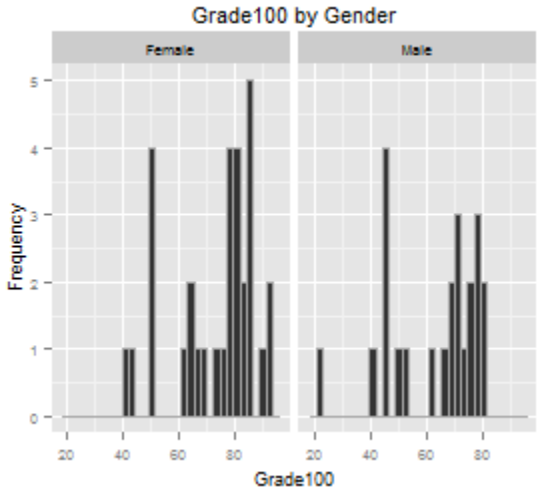

Motivation M/F
Frequency
Motivation
0
5
10
150
200
250
300


Motivation by Gender
Female
Male
Frequency
Motivation
0
2
4
6
150
200
250
300


StdGrades M/F
Frequency
StdGrades
0
3
6
9
0
25
50
75
100


StdGrades by Gender
Female
Male
Frequency
StdGrades
0.0
2.5
5.0
7.5
0
25
50
75
100


Grade100 M/F
Frequency
0
2
4
6
20
40
60
80
Grade100


Grade100 by Gender
Female
Male
Frequency
0
1
2
3
4
5
20
40
60
80
Grade100

Appendix D

Study 1 – A multiple regression analysis

Table D-1. Model Summary Table

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.255[a]	.065	.057	26.69653	.065	8.307	1	119	.005

Predictors: (Constant), MSdeterm; b. Dependent Variable: StdGrades

Table D-2. ANOVA Table

Model		Sum of Squares	df	Mean Square	F-value	Sig.
1	Regression	5920.480	1	5920.480	8.307	.005[b]
	Residual	84811.870	119	712.705		
	Total	90732.351	120			

a. Predictors: (Constant), MSdeterm; b. Dependent Variable: StdGrades

Table D-3. Coefficients Table

Model	Unstandardized Coefficients		Standardized Coefficients	t-value	Sig.	95.0% Confidence Interval for B	
	B	Std. Error	Beta			Lower Bound	Upper Bound
1 (Constant)	11.513	16.979		.678	.499	-22.108	45.133
MSdeterm	1.933	.671	.255	2.882	.005	.605	3.261

a. Dependent Variable: StdGrades

Table D-4. Excluded Variables Table

Model		Beta In	t-value	Sig.	Partial Correlation	Collinearity Statistics		
						Tolerance	VIF	Minimum Tolerance
1	Hope	-.057[b]	-.588	.558	-.054	.852	1.174	.852
	Pride	.058[b]	.603	.548	.055	.859	1.165	.859
	CareerG	-.063[b]	-.689	.492	-.063	.941	1.063	.941
	Interest	.068[b]	.681	.497	.063	.799	1.252	.799
	ExtMotive	-.031[b]	-.334	.739	-.031	.943	1.060	.943
	IntMotive	-.049[b]	-.523	.602	-.048	.911	1.097	.911
	Manxiety	.101[b]	1.136	.258	.104	.991	1.009	.991
	Usefullness	-.054[b]	-.601	.549	-.055	.981	1.020	.981
	MSbelief	.091[b]	.920	.359	.084	.810	1.235	.810
	AchGoal	.052[b]	.545	.587	.050	.876	1.142	.876

a. Dependent Variable: StdGrades; b. Predictors in the Model: (Constant), MSdeterm

Table D-5. Residuals Statistics Table

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	40.5068	75.2997	59.9480	7.02405	121
Residual	-57.89325	41.13558	.00000	26.58506	121
Std. Predicted Value	-2.768	2.186	.000	1.000	121
Std. Residual	-2.169	1.541	.000	.996	121

a. Dependent Variable: StdGrades

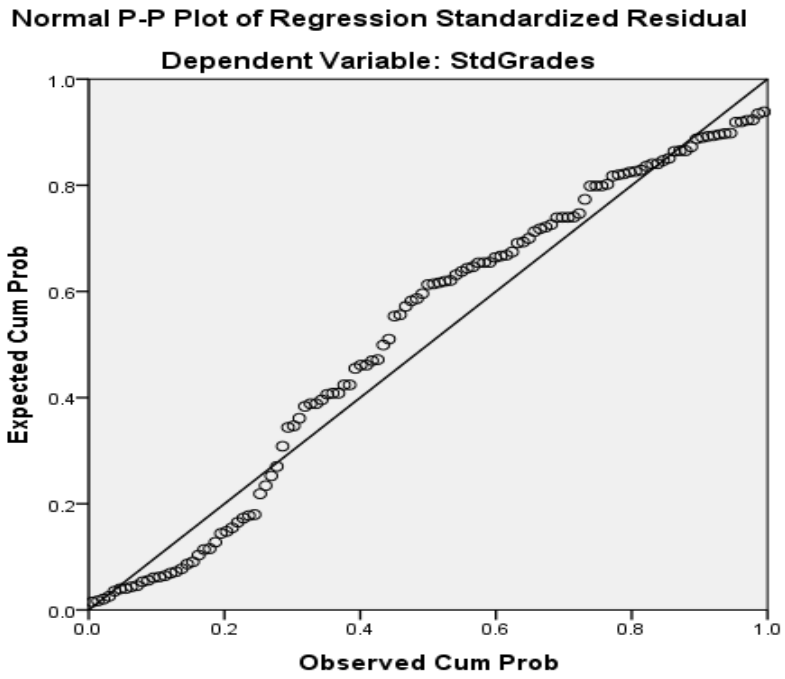


Figure D-1 Normal P-P plot of standardized residuals

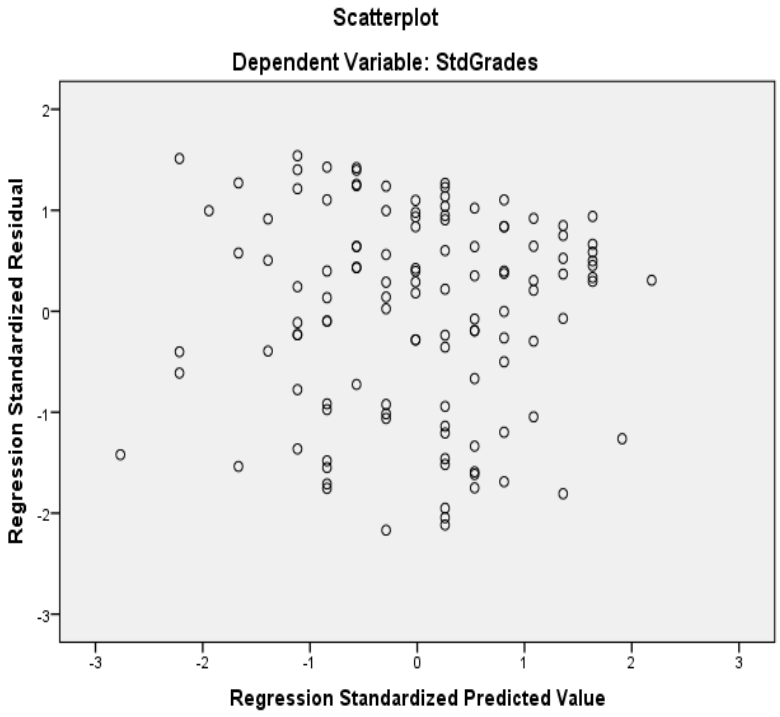


Figure D-2 A scatterplot of the standardized residuals

Appendix E

Study 2 – A mediation and moderated mediation analysis

Table E.1 Mediation analysis (intrinsic motivation) table

Model = 4						
Y = Grade100						
X = Motives						
M = IntMotive						
Sample size						
67						
Outcome: IntMotive						
Model Summary						
R	**R-sq.**	**F-value**	**df1**	**df2**	**p-value**	
0.6833	0.4669	56.9291	1	65	0.0000	
Model						
	Coeff	**SE**	**t-value**	**p-value**	**LLCI**	**ULCI**
Constant	0.979	3.7175	0.2634	0.7931	-6.4453	8.4033
Motives	0.1963	0.026	7.5451	0.001	0.1443	0.2483
Outcome: Grade100						
Model Summary						
R	**R-Sq**	**F-value**	**df1**	**df2**	**p-value**	
0.2611	0.0682	2.3416	2	64	0.1044	
Model						
	Coeff	**SE**	**t-value**	**p-value**	**LLCI**	**ULCI**
Constant	32.234	14.3975	2.2389	0.0286	3.4718	60.9965
IntMotive	-0.2005	0.4801	-0.4176	0.6776	-1.1597	0.7586
Motives	0.2532	0.1379	1.8357	0.071	-0.0223	0.5288

TOTAL EFFECT MODEL						
Model Summary						
R	**R-Sq**	**F-value**	**df1**	**df2**	**p-value**	
0.2562	0.0656	4.5668	1	65	0.0364	
Model						
	Coeff	**SE**	**t-value**	**p-value**	**LLCI**	**ULCI**
Constant	32.0379	14.2981	2.2407	0.0285	3.4824	60.5933
Motives	0.2138	0.1001	2.137	0.0364	0.014	0.4137
TOTAL, DIRECT, AND INDIRECT EFFECTS						
Total effect of X on Y						
Effect	**SE**	**t-value**	**p-value**	**LLCI**	**ULCI**	
0.2138	0.1001	2.137	0.0364	0.014	0.4137	
Direct effect of X on Y						
Effect	**SE**	**t-value**	**p-value**	**LLCI**	**ULCI**	
0.2532	0.1379	1.8357	0.071	-0.0223	0.5288	
Indirect effect of X on Y						
	Effect	**BootSE**	**BootLLCI**	**BootULCI**		
IntMotive	-0.0394	0.0881	-0.2159	0.1274		

Table E.2 Mediation analysis (extrinsic motivation) table

Model = 4						
Y = Grade100						
X = Motives						
M = ExtMotive						
Sample size						
67						
Outcome: ExtMotive						
Model Summary						
	R	**R-Sq**	**F-value**	**df1**	**df2**	**p-value**
	0.2946	0.0868	6.1794	1	65	0.0155
Model						
	Coeff	**SE**	**t-value**	**p-value**	**LLCI**	**ULCI**
Constant	17.9088	4.4792	3.9982	0.0002	8.9632	26.8545
Motives	0.0779	0.0313	2.4858	0.0155	0.0153	0.1405
Outcome: Grade100						
Model Summary						
	R	**R-Sq.**	**F-value**	**df1**	**df2**	**p-value**
	0.3383	0.1145	4.1368	2	64	0.0204
Model						
	Coeff	**SE**	**t-value**	**p-value**	**LLCI**	**ULCI**
Constant	45.1065	15.658	2.8807	0.0054	13.8258	76.3871
ExtMotive	-0.7297	0.3884	-1.8786	0.0649	-1.5057	0.0463
Motives	**0.2707**	0.1027	2.635	0.0105	0.0655	0.476
TOTAL EFFECT MODEL						
Outcome: Grade100						
Model Summary						
	R	**R-Sq.**	**F-value**	**df1**	**df2**	**p-value**
	0.2562	0.0656	4.5668	1	65	0.0364

Model						
	Coeff	**SE**	**t-value**	**p-value**	**LLCI**	**ULCI**
Constant	32.0379	14.2981	2.2407	0.0285	3.4824	60.5933
Motives	**0.2138**	0.1001	2.137	0.0364	0.014	0.4137
TOTAL, DIRECT, AND INDIRECT EFFECTS						
Total effect of X on Y						
	Effect	**SE**	**t-value**	**p-value**	**LLCI**	**ULCI**
	0.2138	0.1001	2.137	0.0364	0.014	0.4137
Direct effect of X on Y						
	Effect	**SE**	**t-value**	**p-value**	**LLCI**	**ULCI**
	0.2707	0.1027	2.635	0.0105	0.0655	0.476
Indirect effect of X on Y						
	Effect	**BootSE**	**BootLLCI**	**BootULCI**		
ExtMotive	**-0.0569**	0.0434	-0.1704	-0.0006		

Appendix F

Study 2 – A moderated mediation analysis

Table F.1 Moderated mediation analysis table

Model = 8						
Y = Grade100						
X = Motives						
M = IntMotive (Intrinsic motivation)						
W = MSbelief						
Sample size						
67						
Outcome: IntMotive						
Model Summary						
	R	**R-Sq.**	**F-value**	**df1**	**df2**	**p-value**
	0.7015	0.4922	20.3513	3	63	0.000
Model						
	Coeff	**SE**	**t-value**	**p-value**	**LLCI**	**ULCI**
Constant	-11.2238	14.3941	-0.7798	0.4385	-39.9882	17.5406
Motives	0.2524	0.1072	2.3544	0.0217	0.0382	0.4666
MSbelief	0.7594	0.6447	1.178	0.2432	-0.5289	2.0478
int_1	**-0.0041**	0.0045	-0.9106	**0.366**	-0.0132	0.0049
Interactions:						
int_1 Motives X MSbelief						
Outcome: Grade100						
Model Summary						
	R	**R-Sq**	**F-value**	**df1**	**df2**	**p-value**
	0.3612	0.1305	2.3258	4	62	0.0662
Model						
	Coeff	**SE**	**t-value**	**p-value**	**LLCI**	**ULCI**
Constant	102.7126	55.4243	1.8532	0.0686	-8.0796	213.5049
IntMotive	-0.2805	0.4828	-0.581	0.5633	-1.2456	0.6846

Motives	-0.3826	0.4285	-0.893	0.3753	-1.2392	0.4739
MSbelief	-2.3405	2.4975	-0.9371	0.3523	-7.333	2.652
int_2	**0.0223**	0.0175	1.2753	**0.2069**	**-0.0127**	**0.0573**
Interactions:						
int_2 Motives X MSbelief						
DIRECT AND INDIRECT EFFECTS						
Conditional direct effect(s) of X on Y at values of the moderator(s)						
MSbelief	**Effect**	**SE**	**t-value**	**p-value**	**LLCI**	**ULCI**
19	0.0414	0.1688	0.2454	0.807	-0.296	0.3788
22	0.1084	0.1556	0.6965	0.4887	-0.2026	0.4194
26	0.1976	0.1645	1.2012	0.2343	-0.1313	0.5266
28	0.2423	0.1794	1.3505	0.1818	-0.1163	0.6009
30	0.2869	0.1994	1.4392	0.1551	-0.1116	0.6854
Conditional indirect effect(s) of X on Y at values of the moderator(s):						
Mediator						
	MSbelief	**Effect**	**BootSE**	**BootLLCI**	**BootULCI**	
IntMotive	19	-0.0488	0.085	-0.2197	0.1151	
IntMotive	22	-0.0453	0.078	-0.2048	0.1028	
IntMotive	26	-0.0407	0.0698	-0.1885	0.0883	
IntMotive	28	-0.0384	0.0664	-0.1842	0.0807	
IntMotive	30	-0.036	0.0634	-0.1795	0.0759	
Values for quantitative moderators are 10th	25th	50th	75th	and 90th percentiles.		
Model = 8						
Y = Grade100						
X = Motives						
M = ExtMotive (Extrinsic Motivation)						
W = MSbelief						
Sample size						

67						
Outcome: ExtMotive						
Model Summary						
	R	**R-Sq**	**F-value**	**df1**	**df2**	**p-value**
	0.3652	0.1334	3.2327	3	63	0.0281
Model						
	Coeff	**SE**	**t-value**	**p-value**	**LLCI**	**ULCI**
Constant	35.1741	17.3104	2.032	0.0464	0.5818	69.7664
Motives	-0.0879	0.1289	-0.682	0.4978	-0.3456	0.1697
MSbelief	-0.5363	0.7753	-0.6917	0.4917	-2.0856	1.013
int_1	**0.0054**	0.0055	0.998	**0.3221**	-0.0055	0.0163
Interactions:						
int_1 Motives X MSbelief						
Outcome: Grade100						
Model Summary						
	R	**R-Sq**	**F-value**	**df1**	**df2**	**p-value**
	0.4538	0.2059	4.019	4	62	0.0058
Model						
	Coeff	**SE**	**t-value**	**p-value**	**LLCI**	**ULCI**
Constant	139.6216	54.4119	2.566	0.0127	30.8531	248.3901
ExtMotive	-0.9598	0.3836	-2.5018	0.015	-1.7267	-0.1929
Motives	-0.5378	0.394	-1.365	0.1772	-1.3255	0.2498
MSbelief	-3.0683	2.3698	-1.2947	0.2002	-7.8055	1.669
int_2	**0.0287**	0.0167	1.7141	**0.0915**	-0.0048	0.0622
Interactions:						
int_2 Motives X MSbelief						
DIRECT AND INDIRECT EFFECTS						
Conditional direct effect(s) of X on Y at values of the moderator(s):						
MSbelief	**Effect**	**SE**	**t-value**	**p-value**	**LLCI**	**ULCI**
19	0.0075	0.14	0.0539	0.9572	-0.2724	0.2875

22	0.0937	0.1292	0.7247	0.4714	-0.1647	0.352
26	0.2085	0.1438	1.4499	0.1521	-0.0789	0.4959
28	0.2659	0.1613	1.6482	0.1044	-0.0566	0.5884
30	0.3233	0.1834	1.7632	0.0828	-0.0432	0.6898
Conditional indirect effect(s) of X on Y at values of the moderator(s):						
Mediator						
	MSbelief	**Effect**	**Boot SE**	**BootLLCI**	**BootULCI**	
ExtMotive	19	-0.0149	0.058	-0.1734	0.0602	
ExtMotive	22	-0.0306	0.0521	-0.1645	0.043	
ExtMotive	26	-0.0515	0.0625	-0.2077	0.0396	
ExtMotive	28	-0.062	0.0733	-0.2398	0.0475	
ExtMotive	30	-0.0724	0.0862	-0.2798	0.0631	
Level of confidence for all confidence intervals in output: 95.00						