# Exploring Persistence in Science in CEGEP: Toward a Motivational Model

Rebecca A. Simon

Department of Educational and Counselling Psychology

McGill University, Montreal

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## Abstract

There is currently a shortage of science teachers in North America and continually decreasing rates of enrollment in science programs. Science continues to be the academic domain that sees the highest attrition rates, particularly for women. The purpose of the present study was to examine male and female students' experiences in mathematics and science courses during a crucial time in their academic development in an attempt to explain the high attrition rates in science between the last year of high school and the first year of CEGEP (junior college). In line with self-determination theory (Deci & Ryan, 1985), as well as achievement-goal theory (Pintrich & Schunk, 1996) and research on academic emotions, the study examined the relation between a set of motivational variables (i.e., perceptions of autonomy-support, self-efficacy, achievement goals, and intrinsic motivation), affect, achievement, and persistence. A secondary objective was to test a motivational model of student persistence in science using structural equation modeling (SEM). The sample consisted of 603 male and 706 female students from four English-language CEGEPs in the greater Montreal area. Just prior to beginning CEGEP, participants completed a questionnaire that asked about the learning environment in high school mathematics and science classes as well as student characteristics including sources of motivation, personal achievement goals, and feelings of competence. All students expressed an initial interest in pursuing a career in science by enrolling in optional advanced mathematics and science courses during high school. Multivariate analysis of variance was used to examine differences among male and female students across the variables measured. Structural equation modeling was used to test the validity of a questionnaire designed specifically to gather information about CEGEP students' experiences with mathematics and science, and to evaluate the fit of a model designed to reflect the interactions between the different variables. Students' experiences during high school have an impact on their decisions to pursue or abandon their path toward an eventual science career. Classroom experiences and student characteristics interact to influence their performance and affect, which in turn influence their decisions. Implications for promoting persistence in science are discussed.

Résumé

Il existe présentement un manque d'enseignants en sciences en Amérique du Nord et une baisse d'inscriptions dans les programmes scientifiques. La science constitue le domaine où le taux d'attrition est le plus élevé, surtout chez les femmes. La présente recherche vise à examiner les expériences des étudiants dans leurs cours de sciences et de mathématiques à un moment crucial dans leur développement académique afin d'expliquer le taux élevé d'attrition entre la dernière année du secondaire et la première année du CEGEP. Dans la lignée des théories de l'auto-détermination (Deci & Ryan, 1985), des buts d'accomplissement (Pintrich & Schunk, 1996) et de la recherche sur les émotions académiques, la présente étude a examiné la relation entre certaines variables motivationnelles (i.e., perceptions du soutien à l'autonomie, sentiment de compétence, buts d'accomplissement, motivation intrinsèque), l'affect, la réussite, et la persévérence. Un objectif secondaire était de tester un modèle de la persévérence en sciences en utilisant la modélisation d'équations structurales (SEM). L'échantillon était constitué de 603 hommes et 706 femmes, issus de quatre CEGEP anglophones de Montréal. Avant de commencer le CEGEP, les participants ont complété un questionnaire les interrogeant sur leur environnement d'apprentissage au secondaire en sciences et en mathématiques, de même que sur leurs sources de motivation, leurs buts personnels d'accomplissement, et leurs sentiments quant à leur compétence. Tous ont exprimé un intérêt initial pour la poursuite d'une carrière scientifique en s'inscrivant dans des cours d'option enrichie en mathématiques et en sciences au secondaire. L'analyse de la variance à plusieurs variables a été utilisée pour examiner les différences entre hommes et femmes quant aux variables mesurées. La modélisation d'équation structurale a été utilisée pour tester la validité d'un questionnaire spécifiquement conçu afin de colliger de l'information au sujet des expériences de cégépiens en mathématiques et en sciences, et pour évaluer l'ajustement d'un modèle conçu pour montrer les interactions entre différentes variables. Les expériences des élèves durant le secondaire ont un impact sur leur décision de poursuivre ou d'abandonner leur cheminement vers une carrière éventuelle en science. Les expériences en classe et les caractéristiques étudiantes interagissent, influençant la performance et l'affect, et par-delà leurs décisions. Les implications de la promotion de la persistance en sciences sont abordées.

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# Chapter 1

## *Introduction*

Student persistence in the sciences deserves close attention given the alarming attrition rates from such programs–especially for women–as well as the current shortage of science teachers in various regions of North America (Ingersoll, 2003). Despite a continuing rise in the number of students attending college, there has been a steady decline in the number of students preparing to teach science. Over the past twenty years the number of college-bound students interested in science or engineering majors has dropped by 50% and as many as half of the students who do enter science programs transfer out before completing their degree (Daempfle, 2002). The physical sciences and engineering are at particular risk, with declines in the number of earned doctorates in these fields in the past decade (National Center for Educational Statistics, 2007). There is no doubt, therefore, that efforts need to be made to encourage more students to pursue such endeavors. Moreover, it is equally important to train future scientists and science teachers effectively since it may have a positive influence on one of the potential causes of early science dropout (i.e., ineffective teaching of science and mathematics; Davis & Steiger, 1996).

*Quebec's CEGEP Education System.* The term CEGEP is an acronym for "Collège d'Enseignement Général et Professionnel". Quebec students attend CEGEP after high school and before university. A DEC (Diplôme d'Etudes Collégiales), obtained upon graduation from CEGEP, is a requirement for all Quebec students who wish to pursue subsequent studies in Quebec universities. There are currently forty-eight provincially funded, tuition-free CEGEPs throughout the province of Quebec, and four

English-language ones in the greater Montreal area. The majority of students attending CEGEP are sixteen to nineteen years old. CEGEPs offer two-year pre-university programs (e.g., Health Sciences) as well as one- to three-year technical/career programs (e.g., Nursing). Students take core courses in English, French, Humanities and Physical Education, as well as a number of specialized courses in their chosen program. Students are admitted to the different science programs at CEGEP on the basis of their performance in high school mathematics, chemistry and physics courses. Typically, they must have an average of at least 70 to 80 percent in their high school science courses in order to be accepted into the CEGEP science program. Because of this stringent requirement, CEGEP science students are often the highest performing students from Quebec high schools.

Examining newly admitted CEGEP students is particularly relevant given that it is during the transition from high school to university that the greatest proportions of science-bound students decide to leave the sciences and switch to non-science majors. In fact, the greatest loss of potential science students occurs just prior to, or shortly after, enrollment in university (Daempfle, 2002). According to Astin and Astin (1993), in the U.S. there is a 40% drop in the number of students intending to pursue careers in the sciences or mathematics between high school and the first year of university.

In the province of Quebec, in grades 10 and 11, academically talented students are given the option of enrolling in advanced mathematics, physics, and chemistry courses. These courses are prerequisites for entry into any CEGEP science program. Students who choose to enroll in these courses tend to be high achieving students who are interested in the sciences and who hope to pursue future careers in science. However, many students who take these optional science courses during high school, despite high achievement, do not end up enrolling in a science program in CEGEP. It is this troubling situation that is the focus of the present study.

In a study of a 2003 cohort enrolled in four public English-language CEGEPs (Rosenfield et al., 2005), approximately half of the students who demonstrated an aptitude for and an interest in pursuing a career in science during high school (by their choice of courses and the grades received in those courses) intended to enroll in a program other than science in university. In fact, there was a steady decrease in the number of students pursuing a path toward an eventual science career between grade 10 and university. As can be seen in Figure 1 below, at every stage a significant proportion of students decided to abandon the sciences and opt for other programs. By the time students were preparing to apply to university, only 49.8% of women and 56.4% of men who enrolled in advanced science courses in secondary 4 were planning on enrolling in a science program in university. The largest drop in the number of students pursuing a path toward an eventual science career occurred between the last year of high school and the first year of CEGEP. The present study sought to understand the experiences of those students who were initially interested in pursuing science careers in grades 10 and 11 and the decisions they made to either enroll in science in CEGEP or enroll in another subject area.

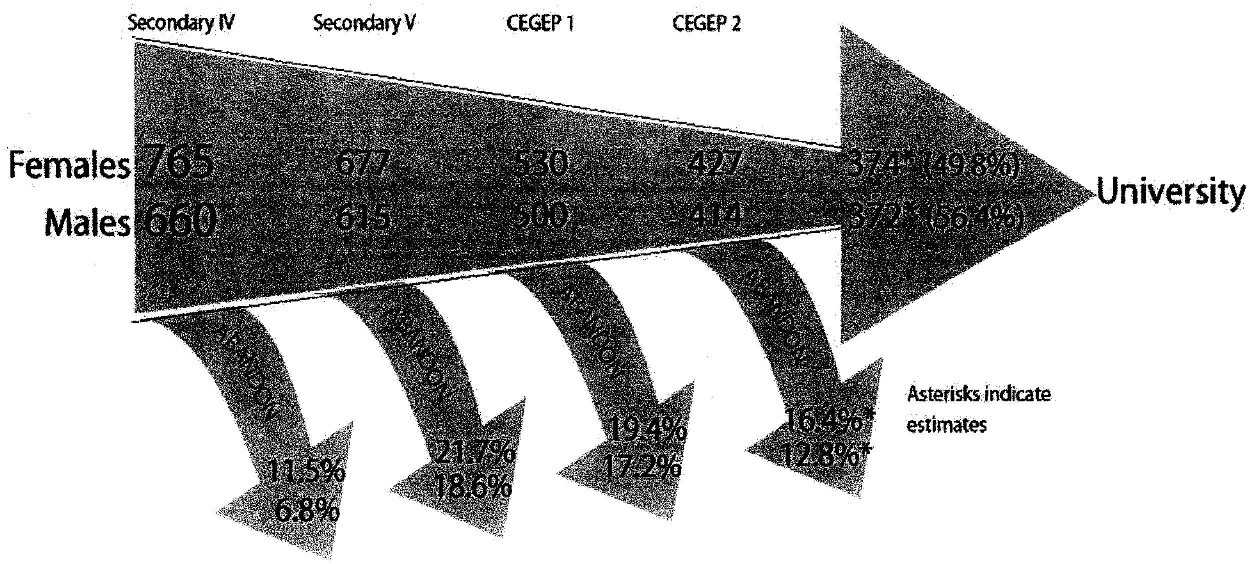


*Figure 1.* Decline in numbers of students in science programs (Rosenfield et al., 2005).

When exploring issues of persistence in the sciences, it is essential to examine the role of sex. The research literature examining sex differences in science enrollment, achievement, and employment underline the need to find ways of attracting and retaining more women in the sciences. According to recent studies on the cognitive abilities of men and women, the sexes do not differ in their intrinsic aptitude for mathematics and science (Spelke, 2005; Waber et al., 2007). At every level of education, despite equal ability, more males than females decide to leave school before completing their degrees. Science is the only academic area in which more females tend to leave than males (Kardash & Wallace, 2001; Seymour & Hewitt, 1997). In a review of research by Strenta, Elliott, Adair, Matier, and Scott (1994), persistence rates for males in undergraduate science and mathematics majors varied between 61% for highly selective institutions and 39% for national samples, as compared to 46% and 30% respectively for women. Mau (2003) examined persistence in science-career aspirations in a U.S. national sample of high school students. Twenty-four thousand five hundred ninety-nine students from 1,052 middle schools initially completed questionnaires regarding career aspirations and a number of social and psychological variables, including academic self-efficacy, self-esteem, locus of control, parental involvement, and achievement, and the same students were followed in grades 10, 12, and two years after having left high school. Male students were more likely than female students to persist in their science career aspirations across the six years of the study. Furthermore, mathematics self-efficacy was found to be the best predictor of persistence in science-career aspirations among a variety of psychological, family, and school variables, and female students were found to have lower levels of mathematics self-efficacy than male students.

Although there has been a steady increase over the past decade in the number of women enrolling in high school level science courses and undergraduate science programs, there are still significant sex inequalities in enrolment patterns at the graduate and career levels. In fact, the number of women pursuing careers in science is small in relation to the number of women trained in that discipline. Furthermore, the higher one goes in any scientific hierarchy (i.e., high school to university to careers in science), the lower is the percentage of women (Committee on Maximizing the Potential of Women in Science and Engineering, 2007). Women continue to enter universities in large numbers, but their numbers have not changed the pattern of sex-role stereotypical disciplines. Women outnumber men at all university levels in the humanities, education, and social and behavioral sciences. In mathematics, computer science, and engineering, however, women represent only 25% of students enrolled (Statistics Canada, 2007). In terms of women's presence in science-related academic positions, the pattern again mirrors the sex-typed pattern of enrolment. Women in 2003-2004 represented 47% of education faculty, 41% of fine and applied arts and humanities faculty, 39% of health professions and occupations faculty, 33% of social science faculty, but only 15% of mathematics and physical science faculty and 11.2% of engineering faculty (Drakich & Stewart, 2007). Women now earn more than one half of all bachelor's degrees in Canada and the U.S., and in the life sciences, chemistry, and mathematics, almost half of all bachelor's degrees are now earned by women (Ivie & Stowe, 2000). However, women are underrepresented among science graduates (roughly one-third of the total number of degrees in science are earned by women, despite outnumbering men both in the general population, and the population graduating from university). Women are particularly underrepresented in the areas of physics, mathematics, and engineering. Forty-two percent of high school students taking physics are women, a dramatic increase from a decade ago. Unfortunately, this percentage drops significantly at the university level where women are still underrepresented at both the undergraduate and graduate level. In 1998, just 19% of physics bachelor's degrees, 20% of physics master's degrees, and 13% of physics PhDs were awarded to women (Mulvey & Nicholson, 2000). In that same year, only 22% of undergraduate students in engineering and applied sciences, and 29% of undergraduate students in mathematics were women. By the time they reached graduate school, only 16% of doctoral students in engineering and applied sciences and 23% of doctoral students in mathematics were women (Statistics Canada, 2000). Therefore, although women have made significant gains in their participation in the field of science over the past few decades, the magnitude of this progress depends on the specific scientific area considered. Furthermore, these gains have not been manifested beyond education into careers in the sciences. It has been estimated that women represent roughly 21% of engineering, mathematics, and natural science professionals (Statistics Canada, 2000). In 2002, women in the U.S. had only 5% of the tenured professorships in physics departments (Ivie & Ray, 2005).

Daempfle (2002), in a study of attrition rates among first year college science majors, noted that the sciences have the largest attrition rate of any undergraduate major and that they have the lowest transfer rates from any other major. In other words, although many students drop out of science to enroll in other programs, few leave other programs in order to switch into science. Possible reasons for attrition are numerous and complex but an understanding of these reasons is essential if we are to implement successful intervention strategies and invest in appropriate resources, to decrease attrition rates and promote academic success and persistence for all students, and especially women.

In today's competitive and technologically advanced society, it is imperative that secondary and postsecondary institutions shape enough competent and knowledgeable scientists and mathematicians to fulfill the needs of such a society. The present study aims at understanding the factors that influence students' decisions to pursue their interests in the sciences beyond high school to CEGEP. If we better understand the experiences of science students during a crucial time in their career development, we may be better equipped to implement necessary changes (e.g., the manner in which the sciences are taught). Such changes may result in more students becoming interested in, and subsequently pursuing, careers in the sciences.

The present study is part of a larger, *FQRSC-MEQ action concertée* funded research project entitled, "A study of the factors influencing the success and retention of students in CEGEP science programs" (Rosenfield et al., 2005). The goal of the larger project was to understand how different perceptions of learning environments in science and mathematics interact with student characteristics (e.g., attitudes, motivation, epistemological beliefs, culture), in order to promote student attraction to and persistence towards eventual careers in the sciences, engineering or science education. These learning environments were examined both in high school (through the perspectives of students entering CEGEP) and CEGEP (through the perspectives of students in science programs) from the theoretical perspectives of constructivism and socially shared cognition, as well as recent theories of motivation. The present study is distinct from the larger study in that it focuses specifically on the transition between high school and CEGEP and that it examines the role of a unique subset of variables (i.e., perceptions of the learning environment, self-efficacy, achievement goals, affect, motivation and achievement). These variables are examined using a structural equation model designed for the present study. In addition, the study tests the validity of a measurement instrument (i.e., questionnaire) developed specifically for the study.

# Chapter 2

## *Literature Review*

### *Causes of Attrition in Science*

Students decide to switch out of science for many reasons. They may lose interest, not perform up to the required standards, or experience life circumstances that make their original career plans unfeasible. With respect to the higher attrition rates for women in science, researchers generally agree that differences between the male and female brain, and differences in the relevant cognitive abilities of males and females, do not exclude women from science and that, instead, psychological and educational influences are most likely at the root of it. In particular, research has found a significant influence of classroom factors (e.g., student-teacher interaction, pedagogy, classroom culture; Seymour & Hewitt, 1997; Tinto, 1987) as well as motivational factors within the student (e.g., motivation, achievement goals, self-efficacy) in determining whether students pursue their career aspirations (Pintrich & Schunk, 1996; Vallerand, Fortier, & Guay, 1997).

### *Self-Determination Theory*

Self-determination theory (SDT) has emerged as an influential motivational theory to explain students' engagement, enthusiasm and continued interest in education and learning (Deci & Ryan, 1985). Self-determination theory focuses on both the content of the goals that individuals have for learning and the learning context within which these goals are pursued. In SDT, humans are conceived of as "active, growth-oriented organisms that innately seek and engage challenges in their environments attempting to actualize their potentialities, capacities, and sensibilities" (Deci & Ryan, 2002, p. 8). In other words, people are not seen as passive recipients of knowledge and experience but rather individuals are continually looking for opportunities to learn and grow. However, this motivation or self-determination is not solely the result of innate tendencies. Rather, social environments act to either facilitate or inhibit a natural tendency toward growth. Therefore, according to self-determination theory, individuals are born with a natural striving to exercise and elaborate their interests, but the social environment determines whether they can pursue their involvement in the chosen area. Motivated actions are perceived of as being self-determined when they are engaged in truly volitionally and when the perceived locus of control is internal to the self. People can be motivated to engage in behaviors in order to gain tangible rewards or to avoid punishment, but this type of motivation is externally controlled and therefore not self-determined. According to SDT, there are three necessary conditions for the growth and well being of individual's personalities, just as there are for their physical development and functioning. With respect to student persistence, these basic psychological needs must be met in order to promote students' continued interest and enjoyment of learning experiences. The three basic needs are autonomy, competence, and relatedness.

Autonomy refers to being the perceived origin or source of one's own behavior. In the context of education, autonomy refers to the students' perception that the learning environment is interactive rather than controlled. Students need to feel that they have some control over what is being taught and that their thoughts and feelings about the material are being acknowledged and integrated (Filak & Sheldon, 2003). In contrast, controlling teacher behaviors such as imposing strict deadlines, giving directives without involving the students, and not allowing students to voice opinions that differ from those expressed by the teacher undermine self-determined motivation. The greater the perception of autonomy in the learning environment, the higher the student's self-determined motivation to learn the subject. If students are motivated to learn, they are more likely to persist in the face of challenge.

The need for competence has to do with feeling effective in one's interactions with the social or physical world. In the context of education, competence refers to students' perceptions that they are effective in their learning, and that they have opportunities to exercise and express their capabilities. The need for competence leads people to seek out challenges that are within their capability. Competence has been referred to in different ways by different researchers. When referring to self-determination in the context of a particular academic subject (in this case mathematics and science), competence has been referred to as academic self-efficacy (e.g., Fortier, Vallerand, & Guay, 1995). When students have adequate self-efficacy beliefs, they believe they are capable of meeting the demands of their academic program and seek out opportunities to demonstrate that competence.

Relatedness refers to the need to feel a connection to others while learning and a sense of belongingness in the learning community. In the classroom context, relatedness refers to the need to interact with others in order to promote the enjoyment of a task or lesson (Deci & Ryan, 2000). However, it is the students' perception of relatedness that is important to promote their motivation and not simply the opportunity to interact or work with others in the classroom.

Self-determination theory proposes that when students feel autonomous (rather than controlled), competent (or self-efficacious) and related, they are more likely to be intrinsically motivated and to adopt intrinsic goals that promote continued interest and persistence in a given subject area. Although perceptions of autonomy-support, competence, and relatedness closely interact with one another, the need for autonomy has received the most attention in prior research on self-determination theory (Ryan & Deci, 2000). Relatively few studies have focused specifically on the role of relatedness and those that have done so measured it in inconsistent and unsystematic ways. In most studies that examine the role of relatedness, the authors created items specifically for the given study and so much variation exists in how relatedness has been conceptualized and measured.

Though classroom experiences are often mentioned as an integral component of many theories of student motivation and persistence, few researchers have clearly defined what aspects of the learning environment operate to influence persistence. When defined, learning environments are usually described in vague terms such as relationships with faculty and positive academic and social experiences on campus (Tinto, 1987). Self-determination theory, however, provides a clear framework for understanding what aspects of the classroom environment are essential to promoting motivation and persistence. One advantage is a clear sense of what types of measures can be developed to be sensitive to aspects of the classroom environment that promote student motivation.

Science classrooms are not generally regarded as autonomy-supportive settings. Because high school science courses often involve concepts with which students have little prior experience, these classrooms tend to be teacher-centred with students adopting a more passive than active role. Furthermore, science classrooms are generally more competitive than cooperative, which suggests that a sense of relatedness may be difficult to achieve (Salter, 2003; Tobias, 1990). Self-determination theory is therefore an interesting framework within which to examine persistence in science since this area seems to be one in which the satisfaction of the basic psychological needs is difficult to attain. This may be truer for women than it is for men because research has shown men to enjoy competitive learning situations more than women (Seymour, 1995; Seymour & Hewitt, 1997). The conditions necessary for self-determined motivation according to SDT are likely to be lacking in science classrooms, which may explain in part why so many students, particularly female students, tend to abandon science studies. Examining persistence in science using an SDT framework may therefore shed some light on how science educators can implement certain practices in the classroom to ensure that the conditions necessary for self-determined motivation occur. Indeed, science educators may need to make an extra effort to put these conditions in place since, unlike other subject areas, the conditions that promote self-determined motivation may not naturally occur.

*Self-Determination Theory in Academic Settings*

Vallerand et al. (1997) developed and empirically tested a motivational theory of high school dropout using self-determination theory as a guiding framework (see Figure 2). The model posits that students' academic motivation is mediated by both perceived academic competence as well as perceived autonomy, as measured by students' perceptions of the amount of choice and decision-making ability they have in their schooling. The model posits that when students are confident in their ability to succeed, and when they perceive their learning experiences to be autonomy-supportive (as opposed to controlling), their self-determined academic motivation is enhanced, particularly their intrinsic motivation. When students are academically motivated, they are less likely to drop out and more likely to persist in their studies.

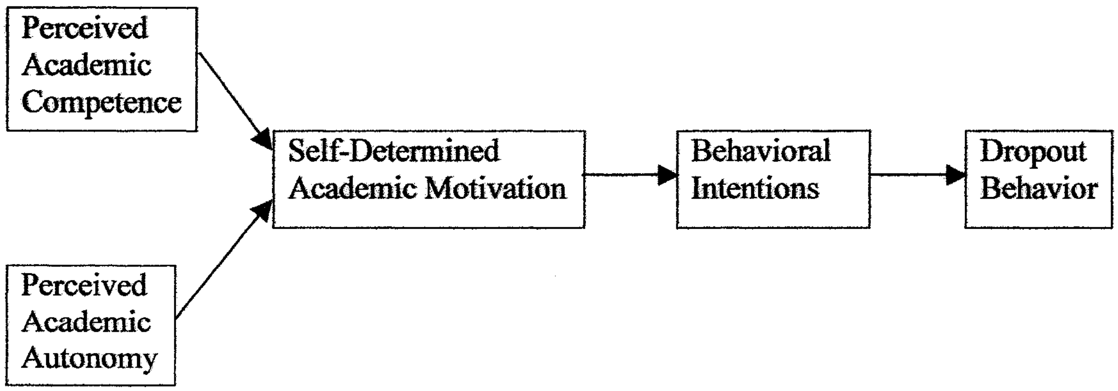


*Figure 2*. The motivational model of high school dropout (Vallerand et al., 1997).

According to Seymour and Hewitt (1997), more than one third of undergraduate students who leave science and engineering majors in college cite poor teaching as the primary reason for changing majors. Colbeck, Cabrera, and Terenzini (2001) examined 1,258 undergraduate students enrolled in engineering courses at seven universities in the United States, and how perceptions of teaching practices and classroom climate impact on students' gains in self-efficacy, motivation, responsibility, and intent to persist. The authors found that students' achievement and persistence were influenced more by teaching practices than by their prior achievement or background characteristics.

The use of inappropriate teaching methods by faculty is an important deterrent to success and persistence in science (Seymour & Hewitt, 1997; Tobias, 1990). Teachers' pedagogical strategies are often driven by pressures to cover a large amount of information outlined in course curricula. As a result, they tend to maintain control over the classroom and progress through the material irrespective of the individual learning differences of their students. Davis and Steiger (1996) reported that student interest in studying science and mathematics declines over the two years at CEGEP as a direct consequence of science instruction and this decline was reported amongst high as well as low achievers.

Several studies have examined the impact of different types of classroom environments on student learning and performance. Specifically, within the context of self-determination theory, researchers have examined the influence of autonomy-supportive versus controlling teacher practices on students' classroom performance and persistence (e.g., Vansteenkiste, Simons, Lens, Sheldon, & Deci, 2004). Much of this research has concluded that the relationship between the learning environment and learning-related outcomes are in fact mediated by students' intrinsic motivation. Research guided by SDT has examined many types of autonomy-supportive and controlling teacher behaviors and has demonstrated that controlling behaviors such as imposing strict deadlines, not allowing students to voice opinions different from those expressed by the teacher, and continually giving directives to students undermine intrinsic motivation by increasing negative feelings and reducing students' active engagement in their learning (Assor, Kaplan, Kanat-Maymon, & Roth, 2005). Contrarily, autonomy-supportive teachers who offer choices to students, allow students to work at their preferred pace, and who build on students' prior knowledge, promote sudents' active engagement in their learning, thereby increasing their intrinsic motivation to learn (Assor, Kaplan, & Roth, 2002).

Church, Elliot, and Gable (2001) examined the relationship between students' perception of the classroom environment and their performance and intrinsic motivation in an undergraduate chemistry course. On the basis of previous motivational research by Elliot and his colleagues (e.g., Elliot & Church, 1997), the authors hypothesized that achievement goals would mediate the impact of the learning environment on students' performance and motivation. Specifically, Church et al. (2001) examined the learning environment as a possible antecedent of students' achievement goals. The authors concluded that indeed the perceived classroom environment has a direct impact on students' goals, which in turn impact their achievement and motivation. Specifically, when students felt engaged and involved in their learning and interested in class material, they tended to adopt mastery goals, which in turn predicted intrinsic motivation and performance. Students who perceived the teacher as controlling and solely concerned with student performance as opposed to student learning tended to adopt performance and avoidance goals, which in turn predicted their performance but not their intrinsic motivation (Church et al., 2001; for a description of achievement goal theory, see p.33).

Therefore, it appears as though the learning environment influences the types of goals that students adopt for themselves in a given course. Depending on the types of goals that students adopt, their intrinsic motivation and academic performance may be enhanced. Students who perceive themselves as involved and engaged in their learning tend to adopt goals that focus on understanding the material rather than focusing solely on test performance. Conversely, when students perceive the classroom environment as non-engaging and performance-oriented, they tend to adopt goals that are performance-oriented.

Valas and Sovik (1993) examined the impact of teacher's controlling behavior on students' intrinsic motivation, achievement and self-efficacy for mathematics in a sample of 335 seventh- and eighth-graders. Using path analysis techniques to test a model based on self-determination theory, the authors concluded that students' perceptions of the learning environment significantly affected their motivation for learning mathematics as well as their feelings of competence in mathematics. Specifically, students who perceived their teacher as supportive of students' autonomy were more intrinsically motivated and considered themselves to be more competent in mathematics than students who perceived their teacher as controlling. In addition, students who perceived their teacher as autonomy-supportive performed at a higher level than those students who perceived their teacher as controlling. Self-efficacy directly predicted students' intrinsic motivation, even when they perceived their teacher as controlling. The results of this study support the links put forth in self-determination theory and point to the importance of both the learning environment as well as students' feelings of competence in promoting their intrinsic motivation and achievement, two major predictors of persistence.

*Women and the Science Classroom*

The disproportionately large loss of women from science majors as compared to men raises the question of whether women view their science classes less favorably than do men. Prior research has shown consistent differences in the types of learning environments preferred by men and women. Knowledge of these learning styles and preferences is essential if teachers and school administrators are to develop teaching practices that promote learning and success for both men and women. Prior research has shown that women tend to view science instruction as too competitive, whereas they tend to prefer a more cooperative learning environment (e.g., Seymour, 1995). For instance, Seymour and Hewitt (1997) found that the competitive classroom culture in science classes played a larger role in women's decisions to switch majors than it did for men. These authors reported that "traditional science pedagogy is inherently disadvantageous to women" (p. 235), and that women's preference for more cooperative learning experiences do not serve them well in the competitive ethos of science classes and contribute to their lower persistence compared with their male peers.

There is much evidence that the sexes are treated unequally in most science classrooms. According to Fennema and Leder (1990), men interact more frequently with teachers than women, and teachers initiate more contacts with men than women. In addition, men receive more praise from teachers than females (as well as more discipline), and teachers respond more frequently to requests for help from men than from women.

*Motivation and Self-Determination*

Motivation plays a key role in both students' academic performance as well as their decisions to persist in their studies in a given academic program until the obtainment of their diploma. Students may be motivated by a variety of factors but whatever the source of motivation, the result is active pursuit of the students' goals, whatever they may be. Motivation has been shown to be a strong predictor of both academic performance and the development of interest in a topic or discipline (Harackiewicz, Barron, Tauer, & Elliot, 2002). For instance, Spence and Helmreich (1983) found that when ability was controlled for, achievement motivation directly predicted undergraduate GPA.

Students can be motivated by different goals and for different reasons. The most basic distinction in theories of motivation is between *intrinsic motivation* and *extrinsic motivation.* Intrinsic motivation refers to doing something because it is inherently interesting or enjoyable, while extrinsic motivation refers to doing something in order to obtain some desired reward (e.g., good grades, approval or recognition of peers or teachers, avoidance of threat or harm). Intrinsically motivated behaviors represent the prototype of self-determination; they emanate from the self and are fully endorsed. Extrinsically motivated behaviors, on the other hand, are performed not out of interest but because they are believed to be necessary in order to obtain some desired outcome (Deci, Vallerand, Pelletier, & Ryan, 1991). According to self-determination theory, autonomous forms of motivation (e.g., intrinsic motivation) lead to positive educational outcomes such as increased interest, involvement and persistence, while less autonomous types (e.g., extrinsic motivation) lead to negative outcomes such as reduced interest, involvement and persistence. More recently, researchers have begun to explore different types of extrinsic motivation and have related certain types of extrinsic motivation to positive outcomes such as academic achievement (Ryan & Deci, 2000). Extrinsically motivated behaviors have been categorized into four types of regulation. *External regulation* is the least autonomous form of extrinsic motivation. It is the prototype of extrinsic motivation, wherein one is motivated to engage in a given behavior to obtain a reward or to avoid punishment. External regulation has an external perceived locus of causality. *Introjected regulation* is a type of extrinsic motivation that has been partially internalized. Introjection-based behaviors are performed to avoid guilt or shame or to enhance feelings of worth. Regulation through *identification* is a more self-determined form of extrinsic motivation in that it involves a valuing of an activity or goal and an acceptance of a behavior as personally important. Identified behaviors tend to have an internal perceived locus of causality and are performed for autonomous reasons. Finally, *integrated regulation* is the most autonomous form of extrinsic motivation. Behaviors governed by integrated regulation are performed volitionally, but unlike intrinsic motivation, they are done to attain personally important outcomes rather than for their inherent interest and enjoyment, and are therefore considered extrinsic. Behaviors governed by integrated regulation appear primarily in adult stages of development and therefore this type of regulation is not typically included in scales assessing self-determined motivation at the high school or college level (Deci et al., 1991). A third type of motivation, called *amotivation,* refers to the state of lacking any intention to act and results from not valuing an activity (Ryan & Deci, 2000). This concept is similar to learned helplessness (Maier & Seligman, 1976) in that the individual experiences feelings of incompetence and uncontrollability (Vallerand, 1997). In the last ten to fifteen years, educational researchers have begun to examine students' motivational styles toward education and how these styles relate to various outcomes such as academic success, persistence, and enjoyment of learning experiences (Fortier et al., 1995). As a result, students who either attend school out of choice (i.e., identified regulation), or for the pleasure and satisfaction experienced while engaging in academic activities (i.e., intrinsic motivation), have been referred to as having an autonomous or self-determined motivational style toward education. On the other hand, students who engage in academic activities because of external pressures (i.e., external regulation), internal controls (i.e., introjection), or students who are not motivated at all (i.e., amotivation) have been referred to as having a non autonomous or non self-determined motivational style (Fortier et al., 1995; Deci & Ryan, 2002). Rather than focusing solely on general motivation when predicting student success and persistence, some researchers have argued that it is equally important to consider situationally specific measures of motivation, which have been referred to as achievement goals (Pintrich & Schunk, 1996). Motivation and goals are intricately linked and both interact to influence student success.

*Motivation and Achievement Goals*

Achievement goal theory has emerged as a predominant framework for understanding students' achievement motivation in academic settings. It was developed within a social-cognitive framework and focuses on the goals or purposes that are pursued in achievement settings (Midgley et al., 1998; Pintrich & Schunk, 1996). Goals provide a framework within which individuals interpret and react to events, and result in different patterns of motivation and behavior. In the context of achievement goal theory, academic goals refer to motives of an academic nature that students use for guiding their classroom behavior and decisions (de la Fuente Arias, 2004). They can encourage students to pursue different academic objectives. These goals are generally categorized into one of three types: (a) Mastery goals (also referred to as learning or task goals) reflect the students' desire to develop competence or ability by acquiring new knowledge or skills. Mastery goals represent a concern with mastering course content, improving one's knowledge and skills, seeking new challenges, and learning as an end in itself. (b) Performance goals (also referred to as performance-approach or ability-approach goals) reflect the students' desire to demonstrate competence or ability relative to others. Performance goals represent a concern with social comparisons, outperforming others, and looking smart. (c) Avoidance goals (also referred to as performance-avoidance or ability-avoidance goals) reflect the students' desire to avoid the demonstration of lack of ability or to exert minimum effort in an activity (Midgley et al., 1998; Urdan, Pajares, &

Lapin, 1997; Elliot & Dweck, 1988). Mastery goals, which focus individuals on increasing their competence over time, have been linked to interest and enjoyment, positive affect, task engagement, deep as opposed to rote learning, and persistence in the face of difficulty (Urdan et al., 1997). Students who adopt mastery goals in academic settings are likely to have intrinsic or internal reasons for pursuing their interests. In contrast, avoidance goals have been linked to decreased interest, enjoyment and performance (Harackiewicz, Barron, Tauer, et al., 2002). Performance goals have elicited more controversy as some researchers have characterized them as having a negative impact on interest and performance, while others have emphasized positive outcomes (Harackiewicz, Barron, Pintrich, Elliot, & Thrash, 2002). Recent studies have suggested that performance goals may in fact be associated with good performance, especially when they occur together with mastery goals (e.g., Elliot & Church, 1997). However, relatively little research has examined the joint and interactive effect of pursuing both types of goals simultaneously. Indeed, it is important to note that students adopt different goals at different times, and may in fact adopt multiple goals in the classroom in order to achieve their desired outcomes. Therefore, students who endorse both mastery and performance goals will be most likely to succeed in school if success is defined in terms of both achievement (i.e., grades), and the development of interest in a topic or discipline.

In a study of 189 eighth grade students from a public school in the U.S., students completed a list of items adapted from the Patterns of Adaptive Learning Survey (PALS; Midgley et al., 1997) measuring their goal orientation, as well as several outcome measures assessing their self-efficacy for mathematics, their mathematics anxiety, and their performance on an end-of-unit mathematics test (Urdan et al., 1997). Results indicated that the relationship between mastery and performance goals was small but positive ($r = .26$). As expected, mastery goals were strongly positively related to all outcome variables. Interestingly, performance goals did not have a negative pattern of relations to the outcome variables. Rather, performance goals were either unrelated or weakly positively related to the performance and motivation variables. However, when sex, GPA, and mastery goals were controlled, performance goals had little effect on motivation and performance outcomes. When performance goals were related to outcomes, this relationship was negative. When students were strong in their pursuit of mastery goals, the simultaneous pursuit of performance goals was not helpful. The authors concluded that intervention efforts should be focused on increasing the emphasis on mastery goals in the learning environment and concentrate less on decreasing the emphasis on performance goals. In other words, rather than focusing on decreasing classroom competition, it is more useful to encourage students to develop a sense of personal mastery of classroom material and to focus on personal learning and growth.

In a longitudinal study by Harackiewicz, Baron, Tauer, et al. (2002), 416 undergraduate students enrolled in an introductory psychology course were followed from their first semester until graduation, in order to examine continued interest in psychology and performance in subsequent classes. Students who adopted mastery goals were more likely to take more psychology courses over their university career than students who did not adopt these goals. In contrast, students who adopted performance goals attained higher grades in all of their classes that semester than students who did not adopt these goals. Students who had high interest in psychology and had high grades in the introductory course were most likely to major in psychology.

Research on motivation and goal orientation has demonstrated a strong positive relationship between mastery goals and intrinsic motivation, performance goals and extrinsic motivation, and avoidance goals and amotivation. Mastery goals are regarded as a precursor to an intrinsic motivational orientation, while performance goals are regarded as a precursor to an extrinsic motivational orientation (Valas & Sovik, 1993). Students who adopt mastery goals tend to be more intrinsically motivated than students who do not adopt such goals, while students who adopt performance goals tend to be more extrinsically motivated than students who do not adopt such goals. In the context of enrolment in CEGEP, students who are mastery-oriented are likely to be intrinsically motivated to attend CEGEP, while students who are performance-oriented are likely to be extrinsically motivated to attend CEGEP.

In an attempt to understand and explain the academic goals that students adopt, Harackiewicz, Barron, Tauer, Carter, and Elliot (2000) examined the role of students' achievement goals in promoting continued interest and performance in undergraduate psychology courses. A series of multiple regression analyses were employed to examine the effect of different types of achievement goals on students' performance and interest both directly after participating in the course, as well as during a follow-up assessment that took place three semesters later. Students' goals were indeed related to their interest in psychology and final grade in the course. Specifically, mastery goals were predictive of interest both during the course and three semesters later, but were not predictive of performance. Conversely, performance goals were predictive of performance but not interest. In the context of persistence, it seems therefore essential to examine the types of goals that students adopt since different goals are related to different academic outcomes.

*Sex and Achievement Goals*

With respect to sex, research has suggested that mastery goals are associated to a greater degree with women, while performance goals are more associated with men (Harackiewicz, Baron, Pintrich, et al., 2002; de la Fuente Arias, 2004). Men are generally viewed as more competitive in classroom settings than women, and this tendency toward competitiveness has been hypothesized to render men more performance-oriented than women. However, this research is fairly limited and overall, sex differences are not explicitly mentioned in studies on achievement goal theory.

*Self-Efficacy and Persistence*

The notion of competence as described in self-determination theory is generally perceived as a general sense of being effective in one's interactions with the world. When referring to the specific context of science education in order to predict specific academic outcomes rather than general well being, the concept of self-efficacy is more appropriate since it is domain specific. Self-efficacy is a performance-based measure of perceived capability rather than a measure of personal qualities such as one's physical or psychological characteristics. From an SDT perspective, supporting people's self-efficacy is likely to satisfy the need for competence. Albert Bandura (1986) developed a theory of human behavior to explain how individuals exert control over their thoughts, feelings, and actions. Social learning theory (Bandura, 1978), or social cognitive theory (Bandura, 1986) as it has been re-named, assumes that over time a broad range of interacting factors in the self and in the environment influences the strength of interest in particular careers as well as persistence in those career aspirations (Farmer, Wardrop, Anderson, & Risinger, 1995). Central to social cognitive theory is the concept of the self-system that mediates between knowledge and action. Specifically, the beliefs individuals hold about their abilities to achieve desired outcomes strongly influence the choices and decisions people make (Bandura, 1986). The central construct in social cognitive theory is *self-efficacy,* which is defined as "the belief in one's capability to organize and execute the courses of action required to produce given attainments" (Bandura, 1997, p. 2). Efficacy beliefs affect behavior by influencing the choices people make, the courses of action they pursue, the amount of effort they will expend, and their persistence in the face of difficulty or failure (Bandura, 1997). In other words, people engage in tasks for which they feel competent and able and avoid engaging in tasks in which they do not. Pajares (1996) argues that the higher the sense of self-efficacy, the greater the effort, persistence, and resilience. Hence, self-efficacy is a very relevant variable to account for in attempting to explain persistence in science from high school to college.

Over the past 10 years the concept of self-efficacy has received increasing attention in research on academic success, motivation, and persistence. In fact, self-efficacy has been identified as a major influence on student performance and persistence. According to Chemers, Hu, and Garcia (2001), "There are some very good reasons for focusing attention more closely on academic self-efficacy as a central determinant of the success of high school to university transitions" (p. 55). Self-efficacy beliefs have been shown to influence such key indices of academic motivation as choice of activities, amount of effort, persistence, and emotional reactions. Self-efficacious students participate more readily, work harder, persist longer, and have fewer negative reactions when encountering difficulty than students who doubt their capabilities (Zimmerman, 2000).

Hackett and Betz (1981) proposed that self-efficacy serves as an important career development mechanism that influences both educational and career decisions as well as achievement and performance. Subsequent research by Lent and Hackett (1987) concluded that self-efficacy is predictive of both college-major choices and academic performance. In a meta-analysis of 39 studies, Multon, Brown, and Lent (1991) explored the relation between self-efficacy beliefs and academic performance and persistence outcomes. Results indicated that self-efficacy beliefs accounted for approximately 14% of the variance in students' academic performance and 12% of the variance in their academic persistence. Effect sizes varied quite a bit (.13 to .58), however, depending on how self-efficacy, performance, and persistence were operationalized in the various studies.

An important issue when examining the role of self-efficacy in predicting academic outcomes is that of measurement. Bandura (1986) has suggested that measures of self-efficacy must be specific to a given domain or task, rather than global generalizations of one's attitudes about one's capabilities. For example, one's efficacy beliefs about performing on a mathematics test may be quite different than one's beliefs about performing on a history test. Especially when attempting to predict particular academic outcomes (e.g., achievement) from self-efficacy measures, one must ensure that the self-efficacy measures correspond to the outcomes being predicted. Because of their greater relevance, domain-specific measures of self-efficacy tend to have higher explanatory and predictive power (Valas & Sovik, 1993).

Research in the area of sex differences in science self-efficacy has consistently shown that men tend to be more confident in their ability to succeed in science and mathematics than women (Eccles, 1994; Lent, Lopez, & Bieschke, 1991; Seymour, 1995). In fact, several persuasive studies support the hypothesis that confidence is the central sex-related predictor of persistence in the area of science and mathematics (Association of American University Women 1990; in Davis & Steiger, 1996). For example, in a study by Valas and Sovik (1993) examining the effects of mathematics teachers' practices on students' intrinsic motivation for mathematics, their achievement and self-concept, ninth grade female students were found to have lower mathematics self-efficacy than male students, despite higher achievement. Numerous studies have explored the roots of women's lower self-efficacy beliefs in the area of science. Such causes tend to involve aspects of women's socialization such as their preference for cooperative learning strategies or the tendency for women to attribute success to effort and failure to lack of ability (Seymour, 1995).

*The Role of Affect in the Science Classroom*

Szulecka, Springett, and de Pauw (1987) suggested that the major causes of attrition in first-year college students are emotional rather than academic (in Pritchard & Wilson, 2003). Larose, Robertson, Roy, and Legault (1998) stated that "Emotional ... dispositions are as important as intellectual assets in the prediction of academic success in college" (p. 277). However, very few studies to date have focused on the emotional experiences of students and how these experiences relate to student success and pursuit of future careers. In fact, emotions have been largely neglected by educational researchers (Pekrun, Elliot, & Maier, 2006). This is surprising given the fact that emotion is often cited as a key element in theories of self-efficacy and motivation. Bandura (1986) underlined the importance of emotion in explaining individuals' self-efficacy. According to social cognitive theory, an individuals' beliefs about his or her own abilities derive from four informational sources, one of which is emotional arousal. If an individual feels anxious, depressed, or ineffectual while performing an academic task, he or she is likely to infer that they are not competent at that task. Contrarily, feelings of happiness, joy, or excitement may enhance perceived self-efficacy (Lent, Brown, & Hackett, 1994). The relationship between affect and self-efficacy is not unidirectional, however, since self-efficacy beliefs also impact emotion. Students' beliefs about their ability to manage academic task demands can influence them emotionally by decreasing their stress and anxiety, and by promoting positive emotions in the classroom (Bandura, 1997). According to Chemers et al. (2001), self-efficacy has an impact on affect "through its effect on attention and construal of environmental demands, by the choice of actions taken, and through its effect on the ability to control and manage negative emotions" (p. 56). Therefore, not only does affect inform self-efficacy beliefs, but these beliefs, in turn, influence one's affect. For example, individuals with high science self-efficacy are less likely to become anxious or depressed while performing a science-related task because they are more likely to expect success and therefore are more likely to feel positive while performing the task. Similarly, individuals with low self-efficacy are more likely to perceive a task as more difficult than it really is and to expect failure and therefore are more likely to feel depressed or anxious while performing the task. In one of the few studies that focus on affect as a predictor of student success, Pritchard and Wilson (2003) found that the use of demographic and academic variables alone did not fully explain the variation in academic success of a sample of 218 undergraduate students. Rather, a students' emotional health was significantly related to both student performance and persistence.

Classroom practices and teacher behaviors are also strongly linked to students' affect. Several studies have found a positive relationship between teachers' autonomy-supportive behaviors and students' positive feelings, and a positive relationship between teachers' controlling behaviors and students' negative feelings both toward the teacher and the instructional content (Assor & Kaplan, 2001). In turn, negative feelings act as internal signals that enhance students' tendency to develop extrinsic motivation or amotivation, which in turn lead to poor engagement in learning and poor persistence (Assor et al., 2005). Students in autonomous learning environments feel engaged in their studies, invest a great deal of effort in learning, tend to be intrinsically motivated, and show high levels of attention and persistence while studying (Assor et al., 2005).

In addition to characteristics of the learning environment, students' achievement goals influence student affect. Specifically, goals are assumed to regulate the achievement-related thoughts and actions that shape students' emotions (Pekrun et al., 2006). Students who adopt mastery goals and feel competent in their ability to succeed in science are likely to experience positive feelings in their classes since these students enjoy learning for the sake of learning. Therefore, these goals are expected to be a positive predictor of the enjoyment of learning and therefore to promote the experience of positive emotions during learning-related activities. In contrast, students who are performance oriented worry about needing to outperform other students and only achieve a positive affective state when they perform better than all other students in their classes, a situation that can be both difficult to achieve and quite precarious. Performance-oriented students are thus more likely to experience negative affect in their classes.

Given women's lower persistence in science as compared to men, it is likely that women would report feeling more negative and less positive in their science classes than men. Also, given women's lower self-efficacy in mathematics and science and the fact that science classrooms are generally more competitive than cooperative, it seems likely that women's classroom experiences would be perceived as less positive. However, very little research focuses on the emotional experiences of men and women in high school mathematics and science and therefore evidence for a clear sex difference in classroom affect is lacking. The present study aims to clarify the mediating role of classroom affect in predicting persistence from student perceptions of the learning environment and student characteristics such as their self-efficacy and achievement goals.

*Achievement and Persistence*

Academic performance is another major predictor of persistence in both academic programs and career aspirations. Bandura (1986) has suggested that among a variety of sources of one's self-efficacy beliefs, past performance constitutes the most influential source of efficacy information. In other words, we infer our sense of competence from the external feedback we have previously received. This hypothesis was supported in a study by Lent, Lopez, and Bieschke (1991). In a regression analysis predicting self-efficacy from the four main sources of self-efficacy described by Bandura (1986), only performance variables explained unique variance in self-efficacy after controlling for sex. Vicarious learning, verbal persuasion, and emotional arousal (the three other sources of self-efficacy according to Bandura), though correlated with self-efficacy in the full sample, did not explain unique variance in self-efficacy. Therefore, it seems as though past performance sets the nature of expectancies of future performance and the sense of control one has over the knowledge one possesses (e.g., one's strategy repertoire and its use).

According to Lent et al. (1991), self-efficacy mediates the effect of prior performance on interest and persistence. Past performance is believed to impact one's self-efficacy beliefs, and those beliefs, in turn, influence interest and persistence. If one's past performance in a particular domain is positive, this promotes one's sense of self-efficacy. Viewing one's self as efficacious is likely to enhance interest in that domain and such interest then motivates persistence in that domain. Prior performance also has a direct impact on future performance, which in turn impacts one's intent to persist. In fact, prior performance has been shown to be the strongest single predictor of future performance (Grandy, 1998). There is no doubt therefore that students who experience academic success in high school mathematics and science courses and receive good grades–most often coupled with positive feedback from teachers–are more likely to infer that they have the capability to continue to succeed in mathematics and science and therefore to choose to enroll in a science program in CEGEP.

With respect to sex, there appear to be differences in science achievement that may contribute to the higher attrition rates for women as compared to men. A comprehensive report from the American Association of University Women (1992) noted that there appears to be a difference in performance levels of men and women depending on whether the instrument used to measure achievement is teacher-made or standardized (Weinburgh, 1995). Research has consistently shown large differences in the performance of men and women on standardized tests of science achievement, in favor of men (Meece & Jones, 1996). The International Association for the Evaluation of Educational Achievement (IEA) initiated the First International Science Study (FISS) between 1966 and 1972 in 19 countries in order to evaluate various national education systems and to explore variables that were thought to be associated with academic achievement (Young & Fraser, 1994). In 1984, a second broader and more comprehensive study was conducted, this time in 24 countries, entitled the Second International Science Study (SISS). The SISS has proven to be a significant database for science-education researchers. The initial data obtained from the FISS suggested that girls consistently performed less well than did boys in mathematics and science. It was also found that girls tended to have less positive attitudes toward science and mathematics than boys (Young & Fraser, 1994).

The Study of Mathematically Precocious Youth (SMPY; Benbow & Stanley, 1982) is another longitudinal study of over 5,000 intellectually talented individuals, identified over a 25-year period (1972-1997). The aim of the study was to develop a better understanding of the unique needs of gifted youth and the determinants of the developmental trajectories they display over the lifespan. No overall sex differences in course taking or course grades in the sciences were found. However, sex differences favoring males were found in performance on high school and college level science achievement tests, in particular the mathematics portion of the Scholastic Aptitude Test (SAT), a measure of mathematical reasoning ability. Benbow and Stanley (1982) suggested that sex differences in mathematical reasoning ability may explain some of the sex differences in science participation both at the academic and career levels.

At the elementary and junior high school levels, the literature on science achievement generally reveals that girls perform at the same level as boys. Beginning at around age 13, however, girls begin to fall behind boys, and by the senior high school level, women select relatively few science electives compared to men, exhibit more negative attitudes toward science, and by the end of high school, women tend to score considerably lower than men in mathematics and science (Oakes, 1990).

In a longitudinal study by Grandy (1998), a sample of 3,840 high-ability students who took the Scholastic Aptitude Test (SAT) was followed for the first five years after finishing high school. The students had to have indicated that they planned to major in science or engineering in university. Students completed a lengthy questionnaire entitled the Postsecondary Experience Survey (PES), which asked about high school experiences, factors influencing career plans, current educational status, and life values. Results indicated that although sex had a statistically significant effect on science achievement, it explained less than 1% of the variance in science achievement. Females reported earning higher science grades in high school than male students, but males earned higher SAT mathematics scores than females. Furthermore, although females did report higher science achievement, males were somewhat more likely to commit themselves to science careers than were females.

*Toward a Model of Student Persistence in Science*

Traditionally, research about student persistence has focused on the causes of school dropout. However, many students change programs without actually leaving school. Much less research examines student choices or decisions to change their academic or career aspirations. The area of science is particularly interesting since student attrition rates remain high from science and engineering programs despite the fact that the demand for qualified scientists and engineers outweighs the number of available individuals (National Science and Technology Council, 2000). Furthermore, examining student persistence during the transition from high school to CEGEP is especially important given the fact that it is during this period that many capable students decide to abandon their plans to pursue their studies in the sciences. Finally, examining the situation in Quebec is particularly relevant given that Quebec universities graduate fewer science graduates than universities in member countries of the Organization for Economic Cooperation and Development (Baillargeon et al., 2001).

Ryan and Deci's (1985) self-determination theory emphasizes the role of perceived autonomy and competence in promoting intrinsic or self-determined motivation and persistence. The proposed model integrates principles from self-determination theory with ones from achievement goal theory as well as the variables of positive and negative academic emotions, and achievement. The model attempts to predict and explain student persistence in the sciences during the transition from high school to CEGEP. Figure 3 below depicts the hypothesized relation between the variables believed to influence students' choices to pursue their science career aspirations.

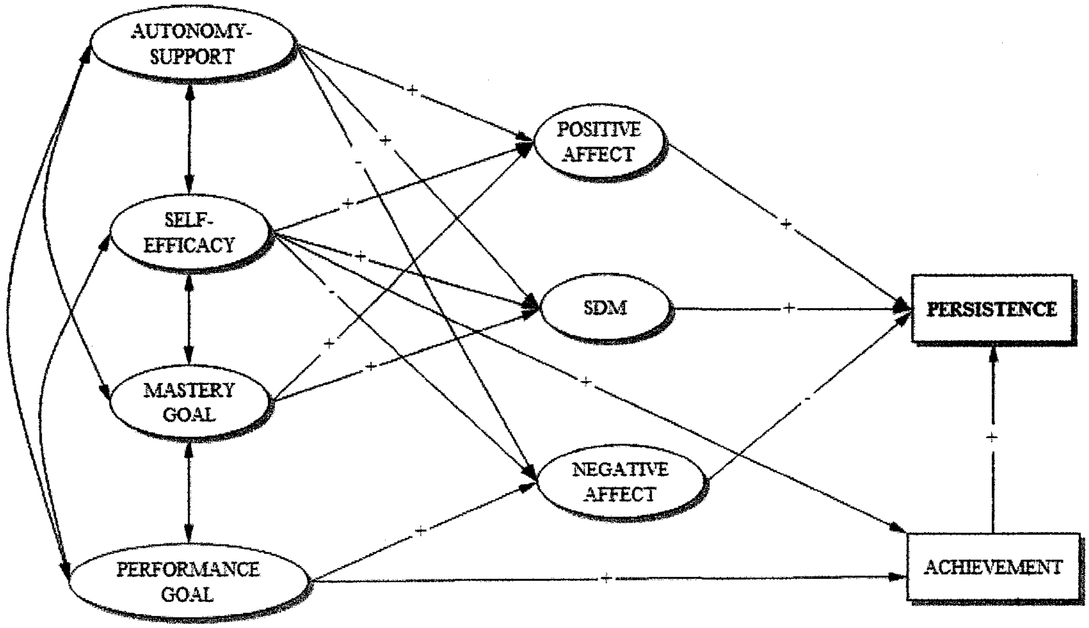


*Figure 3*. Hypothesized structural model of student persistence in the sciences.

Exogenous variables are specified as causes of other variables while the presumed causes of endogenous variables are explicitly represented in the model. The exogenous variables in the model are autonomy-support, self-efficacy, mastery goals and performance goals, which act as independent variables or predictors. An endogenous variable can simultaneously serve in a model as both independent and dependent variables (Kim & Bentler, 2006). In this study self-determined motivation, affect, and achievement are all endogenous variables.

Direct effects are established in SEM by relating exogenous variables to one or more endogenous variables. A direct effect is a regression-like relationship between two variables and involves a direct link between them. The connection is that of a predictor to a dependent variable. An indirect effect is a relationship between two variables that operates through an intervening variable or set of variables. The intervening variable may act as a mediating variable or as an intervening variable that confounds rather than clarifies the nature of a relationship, as a mediating variable will do. Included in the SEM analysis of the proposed model is an estimate of measurement error as well as residual error (i.e., unaccounted for). Error is of course an important part in determining the validity of a model's variable relationships. Although they are not explicitly illustrated in the above model for simplification purposes, the error terms will be included in all subsequent tests of model fit.

The exogenous variables in this study reflect well-established theories of motivation (self-determination theory and achievement goal theory). Hence the exogenous variables all contribute to the endogenous variable of self-determined motivation except for the performance goal variable. It is hypothesized that performance goals will not contribute to self-determined motivation (performance goals are related to non self-determined forms of motivation), but instead will contribute to achievement. Autonomy-support is distinct from the other predictors of motivation because it reflects the instructional context that students have been exposed to in science classes and the extent to which students perceive them to be supportive, while the other variables reflect the self as represented by self-efficacy and goals of mastery and performance held by each individual.

The endogenous variables act as mediators between sources of motivation and persistence. In this function they serve both to predict persistence themselves and to mediate the influence of sources of motivation on persistence. As the literature review indicates, achievement is a strong predictor of persistence in and of itself. However, the literature also shows that if achievement is controlled for, then motivation becomes an important source of variation in whether one does or does not persist in an academic study at a higher level in a particular field. This is further complicated by the finding that the competency dimension of self-determination, as estimated by self-efficacy in the domain of science, also predicts achievement. Hence in a population of students who all achieve at a high level in advanced high school science courses, but still vary in achievement, self-efficacy may weigh more strongly in the decision to persist in science or to enter a different academic major. To further complicate this matter men and women may significantly differ in the extent to which self-efficacy as opposed to achievement alone best explains persistence in science. Separate models will be tested for men and women to examine differences in how these variables interact according to sex.

Affect is also an endogenous variable in the model. It may be predicted by motivation variables and it may predict persistence. However, the literature does not offer strong empirical evidence of its significance as a predictor of persistence. It is hypothesized that it will make a contribution in the case of students who are academically qualified to pursue science and choose to persist. Moreover in a population of students who are achieving well enough to be accepted into a science program in CEGEP, affect may only account for a small proportion of variance in persistence since student self-efficacy should be reasonably strong in these students. The present study proposes that not only do perceptions of autonomy-support and competence influence motivation, but they also impact on students' affective experiences in the classroom. It is therefore hypothesized that students who feel engaged in their learning and have adequate self-efficacy beliefs will report feeling more positive in their science classes than students who do not feel this way. In turn, positive feelings will add to motivation in predicting student persistence, while negative feelings will lead to reduced persistence.

Based on prior research, the goals that students adopt in academic settings may also be associated with variability in affect. Students who are mastery-oriented will likely experience more positive affect in high school science than performance-oriented students because they are more genuinely interested in science subjects, which in turn supports a positive affective state. Contrarily, students who adopt performance goals, and especially women who adopt such goals, should have a more negative affective experience because they worry about outperforming others in a highly competitive environment where it may be very difficult to be the best. What is lacking in the existing empirical literature on student affect is the extent to which students' affective experiences can predict their decisions to pursue their studies in a given domain. Though self-determined motivation will likely play a large role in students' decisions to pursue their science career aspirations, it is believed that the affective experiences of students during their high school mathematics and science courses should add to the prediction of persistence, above and beyond the predictive ability of motivation alone. This may be particularly likely in the present study, which focuses on a cohort of academically strong students who graduated from high school in the summer of 2003 and subsequently enrolled in one of the four public English-language CEGEPs in Montreal in the fall of 2003.

*Research Questions and Hypotheses*

The present study is directed by two major research questions: (a) How do male and female students who either persist or resist in their pursuit of a science career perceive their high school mathematics and science courses, and (b) how well does the proposed model account for male and female students' decisions to enroll in science in

CEGEP? For simplification purposes, students who were enrolled in science are referred to as "persisters," while students who were enrolled in programs other than science are referred to as "resisters."

Within the first major research question, two questions are posed: (a) How do men and women differ in terms of their perceptions of autonomy-support, relatedness, self-efficacy, goal orientation, affect, self-determined motivation and achievement, and (b) how do persisters (i.e., students enrolled in science in CEGEP) and resisters (i.e., students not enrolled in science in CEGEP) differ in terms of these same variables?

Within the second major research question, a number of hypotheses are stated. The following direct relationships were predicted for the model presented in Figure 3 above:

Hypotheses related to autonomy-support:

1a: A positive relation between autonomy-support and self-determined motivation.

1b: A positive relation between autonomy-support and positive affect.

1c: A negative relation between autonomy-support and negative affect.

Hypotheses related to self-efficacy:

2a: A positive relation between self-efficacy and self-determined motivation.

2b: A positive relation between self-efficacy and positive affect.

2c: A negative relation between self-efficacy and negative affect.

2d: A positive relation between self-efficacy and achievement.

Hypotheses related to goal orientation:

3a: A positive relation between a mastery goal orientation and self-determined motivation.

3b: A positive relation between a mastery goal orientation and positive affect.

3c: A positive relation between a performance goal orientation and negative affect.

3d: A positive relation between a performance goal orientation and achievement.

Hypotheses related to affect:

4a: A positive relation between positive affect and persistence.

4b: A negative relation between negative affect and persistence.

Hypothesis related to self-determined motivation:

5: A positive relation between self-determined motivation and persistence.

Hypothesis related to achievement:

6: A positive relation between achievement and persistence.

It was also hypothesized that although the strength of the relationships between variables (i.e., path coefficients) will necessarily differ when the model for the full sample is broken down to compare separate models for the samples of men versus women and persisters versus resisters, the model itself is not expected to differ (i.e., the pattern of variables in the model is expected to remain the same for all groups).

*Anticipated Original Contribution to Knowledge*

This study will contribute to the advancement of knowledge in several ways. First, this study is an original contribution in that the questionnaire used was developed with the specific purpose of reflecting the experiences of CEGEP students with mathematics and science education. Through structural equation modeling, the construct validity (convergent and discriminant) of the questionnaire will be tested and established so that future studies can use it with other populations of students (e.g., Francophone CEGEP students). This measure could therefore be used in subsequent studies of a similar nature. In fact, the researchers involved in the larger project are currently adapting the questionnaire to administer it to the sample of students from this study who graduated from CEGEP and are now enrolled in university. Second, to date there are no existing empirically tested structural equation models of student persistence specifically designed to reflect the experiences of Anglophone CEGEP students in science. This study should shed light on the troubling situation of high attrition rates from the sciences in postsecondary education, especially for women. Thirdly, given that the data were collected in the only four public English-language CEGEPs in Montreal, the results are likely to reflect the experiences of a large portion of urban CEGEP students, allowing for generalizability of the results to the population of English-language CEGEP students. Fourthly, this study hopes to add to the growing body of research on how self-determination theory can be applied to the study of academic persistence. Although some existing research has used an SDT framework to predict student dropout, this study will hopefully shed light on the usefulness of applying self-determination theory to understand students' decisions to persist in science or change their course of study during the transition from high school to CEGEP. In addition, by combining constructs from achievement goal theory to those of self-determination theory, this study seeks to understand how students' achievement goals interact with aspects of the learning environment and students' perceptions of competence in order to predict their motivation and persistence. Since achievement goals influence motivation, adding these goals to a model based on SDT will hopefully add to the predictive validity of SDT alone in predicting motivation and persistence. An additional contribution is that by adding positive and negative affect as predictors of persistence, this study hopes to add a commonly omitted component of students' experiences in science, their classroom affect.

# Chapter 3

## *Method*

### *Participants*

The sample for this study included 1,309 students (*N* = 603 or 46% male and *N* = 706 or 54% female) enrolled at the four public English-language CEGEPs in the greater Montreal area. Students were fairly evenly distributed across the four CEGEPs. Twenty-three point nine percent (23.9%) of participants were enrolled at CEGEP 1, 17.2% were enrolled at CEGEP 2, 28.8% were enrolled at CEGEP 3, and 30.1% were enrolled at CEGEP 4. All students graduated from Quebec high schools in the summer of 2003 and subsequently enrolled in one of the four CEGEPs in the fall of 2003. The mean age of the participants was 17.33 years (range 15 to 19). Nine hundred and seventy eight students (74.7%) were enrolled in a science program and 331 (25.3%) were enrolled in a program other than science. This sample does not represent the distribution of students in science and non-science CEGEP programs. By collecting data in mathematics and science classrooms at some of the CEGEPs, the population of students in non-science programs was not specifically targeted. Consequently, the number of resisters in the sample underrepresents the population of students in non-science programs. In most CEGEPs, the number of students in those programs is often higher than the number of students in science programs.

Of the 706 female participants, 72.7% were enrolled in science (*N* = 513) while 27.3% (*N* = 193) were enrolled in a variety of other programs. Of the 603 male participants, 77.1% were enrolled in science (*N* = 465) while 22.9% (*N* = 138) were enrolled in other programs. Therefore, more women than men were enrolled in programs other than science, thereby reflecting the existing trend of lower persistence in science for women.

The original sample that completed the questionnaire from which the 1,309 students were drawn included 2,096 students across the four CEGEPs. The students from this original sample came from various ethnic and cultural backgrounds. Thirty-eight percent (38%) of students reported English as their mother tongue, 21% reported French, and 41% reported a mother tongue other than English or French. Seventy-eight percent (78%) of students reported being born in Canada, while 22% reported being born in a country other than Canada. Based on available data from 1,282 students, 30.2% of parents had a high school diploma or less, 33.3% had a Bachelor's degree, 25.2% had a Master's degree, and 11.3% had a PhD.

Because I was interested in the choices made by capable students who expressed an interest in pursuing a science career during high school, in order to be included in the final sample, participants had to have taken optional, advanced science courses in grades 10 and 11 and obtained a high school average of 70% or above in their mathematics and science classes, indicating that they had the potential to be admitted into a science program. This cut-off was established based on the admission policies of the CEGEPs for science programs. Of the 2,096 students who completed the questionnaire, 1,352 had taken the advanced mathematics and science courses and obtained a high school average of 70% or above in these courses. Fifteen students failed to indicate in what program they were enrolled in CEGEP and were therefore removed from the final sample. In addition, 10 students were removed because they were aged twenty or older and therefore did not represent the average CEGEP student. These students either took more than the usual five years to complete high school or took time off between graduating from high school and enrolling in CEGEP. Finally, 18 students were removed from the sample following the data screening process because they were considered to be multivariate outliers (Tabachnik & Fidel, 2001). Multivariate outliers are cases with an unusual combination of scores on two or more variables. According to Tabachnik and Fidell (2001), multivariate outliers are best detected through Mahalanobis distance, which is obtained through SPSS REGRESSION. Mahalanobis distance is the distance of a case from the centroid of the remaining cases where the centroid is the point created at the intersection of the means of all variables. In a given data set, the cases form a swarm around the centroid. A case that is a multivariate outlier lies outside the swarm and Mahalanobis distance is a measure of that multivariate distance and it can be evaluated for each case in the data set. Tabachnik and Fidell suggested that multivariate outliers should be removed before conducting data analysis because such cases can skew results. In the context of structural equation modeling, multivariate outliers can affect model fit and parameter estimates.

*Recruitment of Participants and Reinforcements*

All participants (i.e., science and non science majors) completed a questionnaire during the first two weeks of CEGEP. The questionnaire focused on their high school experiences with mathematics and science courses, as well as a variety of personal, social, motivational, and affective variables. A standard form letter was sent home to every newly admitted student (in the fall of 2003) at the four CEGEPs as part of their orientation package (e.g., information about course registration and French placement exams). The letter briefly described the goals and purpose of the larger study and informed students of issues pertaining to confidentiality and incentives to participate. The letter also informed students that there would be a number of cash prizes to be drawn randomly at each CEGEP as an incentive to participate. In total, $600 was distributed at each of the four CEGEPs (one prize of $250, one prize of $100, five prizes of $50). At one of the CEGEPs, students were invited to complete the questionnaire on their assigned orientation day. When students arrived at the CEGEP on their orientation day, a number of volunteers working on the research project greeted them, invited them to participate in the research, and guided them to the assigned room if they agreed to participate. Upon entering the research room, a trained experimenter described the main purpose and objectives of the project, provided standardized instructions to the students and asked them to sign a consent form (see Appendix A). Students then sat down and completed the questionnaire, which took approximately 30 minutes to complete. At the other CEGEPs, students completed the questionnaire in class during the first two weeks of classes. Students completed the questionnaire in a number of classes including mathematics, physics, chemistry, business and humanities. Because more science than non-science classes were targeted, as mentioned above, the sample of resisters in the present study under-represents the population of students enrolled in non-science programs (because these students were less likely to take science classes).

*Development of the Questionnaire*

Because of the lack of any existing comprehensive measure of CEGEP students' experiences with mathematics and science prior to CEGEP entry, a questionnaire was constructed, combining and adapting items from a number of existing scales. The questionnaire focused on students' perceptions of their high school experiences in mathematics and science courses.

All subscales included in the questionnaire (e.g., motivation, self-efficacy, achievement goals, affect) were either taken directly from existing scales or adapted from existing scales to reflect the population in question. The scales have been found to have satisfactory item and subscale estimates of internal consistency, which will be reported subsequently as the questionnaires' construction is discussed.

The questionnaire (see Appendix B) consisted of 130 items assessing a wide range of personal, social, and academic variables. To limit the number of items that each student responded to and encourage complete responses to the questionnaire, four versions of the original questionnaire were created, each containing 110 items. The design of the questionnaire was thus a planned missing-data design (Graham, Taylor, & Cumsille, 2001). All four versions contained the items concerning students' perceptions of the classroom environment. Version one contained the self-efficacy and affect scales, version two contained the motivation and goal orientation scales, version three contained the self-efficacy, affect and goal-orientation scales, and version four contained the self-efficacy, affect and motivation scales. The four versions were randomly distributed to students. As the students entered the research room, they were handed one of the four versions that were each printed on a different colour of paper. The researchers consistently alternated among the four versions when distributing the questionnaires to the students to ensure a random distribution.

*Self-determined motivation.* Self-determined motivation was measured using four items from the Academic Motivation Scale (AMS) developed by Vallerand et al. (1992).

The AMS is an English version of the *Echelle de Motivation en Education* (EME; Vallerand, Blais, Brière, & Pelletier, 1989), developed to assess the academic motivation of postsecondary students within the framework of self-determination theory (Deci & Ryan, 1985). The AMS assesses the three main types of motivation, as described in self-determination theory: It is comprised of 12 items measuring intrinsic motivation, 12 items measuring extrinsic motivation (external regulation, introjected regulation, and identified regulation), and 4 items measuring amotivation. The AMS has satisfactory internal consistency (mean alpha value = .81; Vallerand et al., 1992) and stability over time (mean test-retest correlation = .79; Vallerand et al., 1992). Because the AMS was designed to measure postsecondary students' academic motivation (it was validated on both CEGEP and university samples of students), the scale asks the question: "Why do you go to college?" For the purposes of the present study, the question was altered to better reflect the population in question. The question asked was thus: "Why are you going to CEGEP?" The research team selected two items measuring intrinsic motivation and two items measuring identified regulation as these reflect self-determined forms of motivation. The internal consistency of the reduced scale was satisfactory (mean alpha value = .66). After some consideration however, the two items measuring identified regulation were discarded from the analyses because they were highly skewed (around -2.0) and reduced the overall reliability of the scale. The reliability of the scale including only the intrinsic motivation items was much improved ($\alpha = .75$). Therefore, rather than referring to this variable as self-determined motivation, it will subsequently be referred to as intrinsic motivation, which is the most self-determined form of motivation (see items in Table 1).

*Self-efficacy.* Self-efficacy was measured using 6 items adapted from the Motivated Strategies for Learning Questionnaire (MSLQ), developed by Pintrich, Smith, Garcia, and McKeachie (1991) at the National Center for the Improvement of Postsecondary Teaching and Learning (NCRIPTAL) of the University of Michigan. The MSLQ includes 15 scales, one of which focuses on self-efficacy. A group of CEGEP and university science and mathematics professors reviewed and discussed the self-efficacy scale and chose six items that were most relevant to the present study. The six MSLQ items were then adapted based on feedback received from members of the item-review team to best reflect the experiences of CEGEP science students. The MSLQ item "I believe I will receive an excellent grade in this class" was changed to "I am unsure that my grades in math or science courses will be good" (reversed). The MSLQ item "I am confident I can do an excellent job on the assignments and tests in this course" was changed to "I am confident that my solutions for math and science problems are usually correct." The MSLQ item "I am confident I can learn the basic concepts taught in this course" was changed to "I think I have a good knowledge of basic concepts in math and science." The MSLQ item "I expect to do well in this class" was changed to "I can succeed in math or science classes." The MSLQ item "I am certain I can understand the most difficult material presented in the readings for this course" was changed to "I can do even the most difficult problems in the math or science textbook." Finally, an item was created that was not adapted from any item from the MSLQ, "I write math and science exams much less confidently than exams in other subjects" (see Table 1). The resulting scale had satisfactory internal consistency ($\alpha = .77$).

*Achievement goal orientation.* Students' achievement goal orientation was measured using 12 items from the Patterns of Adaptive Learning Survey (PALS) developed by Midgley et al. (1997). The PALS contains six items measuring a mastery goal orientation ($\alpha = .83$), six items measuring a performance-approach goal orientation ($\alpha = .86$), and six items measuring a performance-avoid goal orientation ($\alpha = .74$). For the purposes of the present study, four items measuring each of the three goal orientation types were selected (see items in Table 1). The resulting reduced scale had adequate reliability (mastery orientation $\alpha = .70$, performance orientation $\alpha = .74$, avoidance orientation $\alpha = .68$).

*Affect.* Affect was measured using eight items from a scale developed by Emmons (1992). Because the researchers were interested in knowing the frequency with which students experienced a number of different emotions during their mathematics and science courses during high school, the items simply consisted of a list of four positive and four negative emotions (joyful, happy, pleased, enjoyment, frustrated, worried/anxious, depressed, unhappy), and students were asked to rate the frequency with which they experienced these emotions on a scale of 1 (very rarely or not at all) to 5 (very often). This scale has been shown to have excellent temporal reliability and internal consistency coefficients that approach .90 (Diener & Emmons, 1984). In the present study, the alpha value for the positive affect scale was .86 and the alpha value for the negative affect scale was .77. The possibility was considered of combining the positive and negative affect scales into one overall affect scale by reversing the scores on negative affect and adding them to the positive affect scale. However, the combined scale had much lower reliability than the two separate scales ($\alpha = .72$), indicating that the two scales are qualitatively different and should not be combined. Therefore, positive affect and negative affect were kept as two separate variables.

*Perceptions of the learning environment.* Student perceptions of the learning environment in mathematics and science classes during high school were measured using 28 high-factor-loading items from the Perceptions of Science Classes Survey (PSCS) developed by Kardash and Wallace (2001). The items tap into several areas of the classroom environment, including pedagogical strategies, faculty interest in teaching, and active versus passive learning. Because this survey was not developed specifically to measure students' perceptions of autonomy-support and relatedness, the investigator chose a subset of items that best described the two perceptions, and confirmatory factor analysis (CFA) was used to determine whether the chosen items truly loaded onto their expected factor. Four items were selected to measure students' perceptions of autonomy-support and five items were selected to measure students' perceptions of relatedness. Confirmatory factor analysis was carried out with EQS (version 6.1). Despite a significant chi-square, results indicated that the model fit the data well ($\chi^2$ (34) = 108.07, $p < .001$, CFI = .96, NNFI = .94, RMSEA = .04) and that all items loaded onto their expected factor (all standardized factor loading were above .4). The resulting coefficient alpha reliability for each measure closely approximated the recommended .7 or above standard with autonomy-support, $\alpha = .67$ and relatedness, $\alpha = .66$ (Johnson & Christensen, 2004; see items in Table 1).

Table 1

*Questionnaire Items*

| | |
|---|---|
| Intrinsic motivation | |
| | I am going to CEGEP because I experience pleasure and satisfaction while learning new things. |
| | I am going to CEGEP for the pleasure that I experience in broadening my knowledge about subjects which appeal to me. |
| Self-Efficacy | |
| | I am unsure that my grades in math or science courses will be good. (reversed) |
| | I am confident that my solutions for math and science problems are usually correct. |
| | I think I have a good knowledge of basic concepts in math and science. |
| | I can succeed in math or science classes. |
| | I can do even the most difficult problems in the math or science textbook. |
| | I write math and science exams much less confidently than exams in other subjects. (reversed) |
| Mastery goal | |
| | I like schoolwork that I'll learn from, even if I make a lot of mistakes. |
| | An important reason why I do my schoolwork is because I like to learn new things. |
| | I like schoolwork best when it really makes me think. |
| | An important reason why I do my schoolwork is because I want to get better at it. |
| Performance goal | |
| | Doing better than other students in school is important to me. |
| | I would feel really good if I were the only one who could answer the teachers' questions in class. |
| | I'd like to show my teachers that I'm smarter than the other students in my class. |
| | I would feel successful in school if I did better than most of the other students. |
| Avoidance goal | |
| | One of my main goals is to avoid looking like I can't do my work. |
| | It's very important to me that I don't look stupid in my classes. |
| | An important reason why I do my schoolwork is so that I don't embarrass myself. |

The reason I do my schoolwork is so my teachers don't think I know less than other students.

Autonomy-support

Teachers attempted to find out what students already know about a topic before presenting new or more advanced information in their classes.

Teachers tried to ensure that their students felt confident and competent in their study of math and science.

Lectures stimulated me to think along with the teacher and to understand new ideas.

Teachers encouraged me to think for myself.

Relatedness

Teachers promoted the idea of 'discovering things together' with students in their classes.

Teachers encouraged students to work together.

Teachers gave a short lecture and then groups of students worked on problems or discussed topics.

When teachers asked groups of students to discuss a topic, the discussion usually improved my understanding.

Teachers encouraged students to participate in classroom discussions.

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*Achievement.* Grades for all students' high school science courses were obtained from government records (*Ministère de l'Éducation, du Loisir et du Sport*). A total science achievement score for high school was computed by taking the mean of students' secondary 4 and 5 science grades from the following courses: secondary 4 mathematics, secondary 4 physical science, secondary 5 mathematics, secondary 5 physics, and secondary 5 chemistry.

*Protocol for the Recording of Data*

The questionnaire consisted of 110 items to be rated on a 5-point Likert scale, ranging from 1 = strongly disagree/very rarely or not at all, to 5 = strongly agree/very often. Students provided their responses on an opscan sheet. All opscan sheets were subsequently scanned and the data were loaded into a database.

*Data Screening*

Data screening involved tests for outliers, normality, skewness, kurtosis and multicolinearity, following the suggestions provided by Tabachnik and Fidel (2001). Extreme univariate and multivariate outliers were assessed with SPSS version 11.5 and removed since outliers can affect model fit indices and parameter estimates. As reported above, 18 cases were identified as outliers and removed from all analyses. Because of the large sample size, these outliers could be removed without affecting power. Examination of univariate skewness and kurtosis for all variables was also carried out with SPSS version 11.5. Although all values of skewness were within the acceptable range (< 1.00), kurtosis values for several variables were somewhat large (> 2.00). Furthermore, analysis of multivariate kurtosis by means of Mardia's coefficient revealed high multivariate kurtosis (> 20). Therefore, in all subsequently explained SEM analyses, the robust method of estimation was used since this method corrects for non-normal data. Specifically, the robust method weighs normal cases more heavily and non-normal cases less heavily (Chou, Bentler, & Satorra, 1991). Although the robust method generally results in lower model fit indices, these indices are more conservative and therefore more trustworthy than indices computed using maximum likelihood estimation.

In order to assess for multicolinearity, a correlation matrix of all variables was examined (see Chapter 4). Bryman and Cramer (1997) suggest that correlations between any pair of variables should not exceed .80 in order to rule out multicolinearity. In the present study, no correlations exceeded .60.

*Analyses*

In order to answer the first research question (i.e., How do male and female students who either persist or resist in their pursuit of a science career perceive their high school mathematics and science courses?), multivariate analysis of variance (MANOVA) was used to examine mean differences in the levels of self-efficacy, achievement goals, motivation, affect, achievement, and perceptions of the classroom environment. MANOVA was used to examine differences both between and within sexes across the different variables. MANOVA was conducted to examine (a) differences between males and females irrespective of the CEGEP program in which they enrolled, (b) differences between persisters and resisters, irrespective of sex, (c) differences between female persisters and female resisters, (d) differences between male persisters and male resisters, (e) differences between female persisters and male persisters, and (f) differences between female resisters and male resisters. Because tests of significance tell us only the likelihood that experimental results differ from chance expectations, effect sizes were also reported for significant results in order to estimate the magnitude of differences between group means. Many researchers assess effect sizes using Cohen's *d* and this measure of effect size is considered to be the method of choice (Thalheimer & Cook, 2002). Cohen's *d* was therefore calculated for significant differences using the following calculation: $d = \frac{M_a - M_b}{s_{pooled}}$, where $M_a$ = mean of group a, $M_b$ = mean of group b, and s = standard deviation. The pooled standard deviation is calculated using the following formula (Thalheimer & Cook, 2002):

$$s_{pooled} = \sqrt{\frac{(n_a - 1)s_a^2 + (n_b - 1)s_b^2}{n_a + n_b}}$$

where $s_a$ = standard deviation of group a, $s_b$ = standard deviation of group b, $n_a$ = number of subjects in group a, and $n_b$ = number of subjects in group b. Cohen (1988) proposed the following standard for interpreting effect sizes: (a) small = around 0.20, (b) moderate = around 0.50, and (c) large = around 0.80 or greater.

In order to answer the second research question (i.e., How well does the proposed model account for male and female students' decisions to enrol in science in CEGEP?), structural equation modeling (SEM) was carried out using EQS software. Several SEM considerations are reviewed below.

*Data Requirements*

*Continuous vs. categorical data.* SEM treats variables as if they were continuous. Therefore, one must use caution when treating categorical variables as if they were continuous. According to Byrne (2001), SEM can provide reliable models when the number of categories is not small (at least 5). In the present study, all variables were assessed using 5 categories (i.e., 5-point Likert scales). In addition, Byrne suggested that using the maximum likelihood (ML) method of estimation is adequate in treating all categorical variables as continuous. In the present study, the robust maximum likelihood (RML) method of estimation was used.

*Sample size.* When using SEM, a general rule of thumb is that one must have at least 200 participants or 15 cases per parameter estimated. Kim and Bentler (2006) suggested that a ratio of 20:1 for the number of participants to the number of parameters is optimum, while a ration of 10:1 is satisfactory. Given the large sample size in the current study ($N = 1,309$), there is no doubt that the sample size is large enough to obtain reliable results.

*Missing data.* Because of the manner in which the questionnaire was constructed (i.e., four versions, each containing different combinations of variables), to test the proposed model, a planned missing-data procedure was used since all participants needed to have data on all variables included in the model (Graham et al., 2001). Historically, when data sets included missing data, participants with missing data were discarded from the analyses thereby reducing the overall sample size and reducing power to the point where results were often non significant. Procedures such as mean substitution or pairwise deletion have been widely used, but research has shown that such procedures yield highly biased parameter estimates (Kline, 1998). Using a missing-data procedure such as the one used in this study and described next makes use of all the available data and therefore avoids throwing away data as a means of achieving a data pattern that is convenient for traditional statistical procedures. It ensures that parameter estimates are unbiased and that the assessment of the variability around those parameter estimates (i.e., standard errors) is reasonable (Graham et al., 2001).

As described above, multiple versions of the questionnaire were created to reduce the workload of the research participants (i.e., to reduce the time taken to complete the questionnaire in order to avoid questionnaire fatigue where participants might just get tired and circle the same number for all items). Given the large number of variables included in the study, the researchers wanted each version of the questionnaire to have a manageable number of items. The distribution of variables included in the four versions of the questionnaire is presented in Table 2 below.

Table 2

*Distribution of Scales Among the four Questionnaire Versions*

| | Scale | | | | | |
|---|---|---|---|---|---|---|
| Version | Autonomy | Relatedness | Self-efficacy | Motivation | Goal orientation | Affect |
| 1 | YES | YES | YES | NO | NO | YES |
| 2 | YES | YES | NO | YES | YES | NO |
| 3 | YES | YES | YES | NO | YES | YES |
| 4 | YES | YES | YES | YES | NO | YES |

Because the four versions were distributed randomly to the participants in each CEGEP, the missing data are randomly distributed. This is an essential condition for using the expectation maximization imputation technique (Little & Rubin, 1987). The expectation maximization (EM) algorithm for covariance matrices is an iterative process. It reads in the data matrix, with missing and non-missing values, and reads out a maximum-likelihood variance-covariance matrix and vector of means. This variance-covariance matrix and vector of means can then be used by the EQS program to further analyze the data using structural equation modeling.

The EM algorithm method involves two steps. In the E-step, the data is read in one case at a time. As each case is read in, one adds to the calculation of the sufficient statistics (i.e., sums, sums of squares, sums of cross products). Non-missing values contribute to the sums directly. When values are missing, a predicted score is generated based on a regression equation with all other variables as predictors. In the M-step, once all the sums have been collected, the variance-covariance matrix and vector of means can simply be calculated. Based on this covariance matrix, the regression equation can also be calculated for each variable as a dependent variable. The regression equation from the first iteration is then used in the next E-step for iteration 2. Another (better) covariance matrix is then produced in the M-step of iteration 2. That covariance matrix and regression equations are used for the next E-step, and so on. This two-step process is repeated until the change in the covariance matrix from one iteration to the next becomes trivially small. The EM method provides maximum-likelihood estimates of the variance-covariance matrix elements that can then be used to test a model using SEM. The key advantage of using a single data set imputed from EM parameters is that one is dealing with a data set with no missing data. Thus, standard statistical software can be used (Little & Rubin, 1987).

The EQS program (version 6.1 for Windows) successfully imputed the missing data using the EM algorithm method and provided maximum likelihood estimates of all the missing data points. The imputed data set obtained through EQS was subsequently used for the structural equation modeling.

*Representing SEM Models*

SEM models are illustrated using path diagrams. Squares represent observed variables (i.e., questionnaire items, achievement and persistence which were directly observed), while latent variables or factors are represented in circles. Latent variables are variables that are not directly observed but are rather inferred from variables that are directly measured. In the present study achievement and persistence are observed variables, while all other variables in the model are latent variables since they are inferred from combinations of questionnaire items. One-headed arrows between two squares or two circles represent causal relations (Byrne, 2001). Arrows not originating from a variable represent the residual error of the variable, and curved double arrows between two variables represent a covariance between those variables. As recommended by Tabachnik and Fidell (2001), significant paths in the model are marked with a star next to the path coefficient while non-significant paths are not. According to Kline (1998), standardized path coefficients with values less than .10 may indicate a "small" effect; values around .30 a "medium" effect; and "large" effects may be indicated by coefficients with absolute values greater or equal to .50.

*Fit Indices*

Based on prior SEM research (e.g., Kline, 1998), five indicators of fit were used to evaluate both the measurement and structural models: the comparative fit index (CFI), the non-normed fit index (NNFI), the chi-square ($\chi^2$), the chi-square to degrees of freedom ratio ($\chi^2$/df), and the root-mean-square error of approximation (RMSEA; Byrne, 2001). The comparative fit index (CFI) is the most widely used indicator of model fit. The CFI compares the null model (covariance matrix of 0s) with the observed covariance matrix to estimate the percent of lack of fit that is accounted for when going from the null model to the model being tested. The CFI indicates the model "goodness of fit," or the extent to which the specified model improves the fit of a model with no relation among the variables. A CFI of .90 is necessary to accept the model, indicating that 90% of the covariation in the data can be reproduced by the given model. The non-normed fit index (NNFI), also called the *Bentler-Bonett non-normed fit index,* also compares the null model with the observed data. It reflects the proportion by which the specified model improves fit compared to the null model. For instance, NNFI = .50 means that the researcher's model improves fit by 50% compared to the null model. By convention, a NNFI above .90 indicates adequate fit. The chi-square ($\chi^2$) is based on a comparison of the predicted and observed covariance matrices. It is therefore a measure of the "badness of fit" meaning that a non-significant $\chi^2$ indicates that the model is an adequate representation of the sample data (Byrne, 2001). For models with a sample size of about 75 to 200, this is a reasonable measure of fit. But for models with more cases, the chi-square is prone to model rejection in virtually any formal test of significance and is almost always statistically significant (Byrne, 1994). Nevertheless, it is a standard index of model fit and will therefore be reported. The chi-square to degrees of freedom ratio ($\chi^2$/df) is also a common measure of model fit. The rule of thumb is that if this ratio is less than 3, it is considered an acceptable fit (Kline, 1998). The root mean square error of approximation (RMSEA) is another widely used estimate of model fit. Hu and Bentler (1995) suggested a cutoff RMSEA of < .05 for a good model fit, but they specified that fit is adequate if the RMSEA is < .08.

*Wald and Lagrange Multiplier Tests*

In addition to the goodness-of-fit tests that determine the adequacy of a given model, two additional tests are commonly used to examine the statistical necessity of sets of parameters that might be added or removed from the model. The Lagrange Multiplier, or LM test, evaluates the effect of adding free parameters to a given model (i.e., reducing restrictions on the model), while the Wald test evaluates the effect of dropping parameters from a more complete model (i.e., adding restrictions to the model). In other words, the LM statistic improves model fit by freeing previously fixed parameters while the Wald statistic improves model fit by fixing previously free parameters. These tests are relatively easily implemented in a single computer run and provide guidance on how a model can be modified to yield improved fit of a model to data (Bentler, 1986). It is important to use these tests with caution. Even though adding or dropping parameters in a model may improve model fit, it is not recommended to implement such changes unless the researcher has a compelling theoretical reason to do so. Therefore, given that all the paths in the model are established based on existing theory and empirical research, non-significant paths will be kept in the model but only significant paths will be marked with a star to highlight their significance.

*Plan*

The structural equation modeling process centers around two steps: validating the measurement model (i.e., questionnaire) and fitting the structural model (i.e., hypothesized relationship among factors). The former is accomplished through confirmatory factor analysis, while the latter is accomplished through path analysis with latent variables.

*Testing the factorial validity of the questionnaire (measurement model).* Kline (1998) urged SEM researchers to test the pure measurement model underlying a full structural equation model first, and if the fit of the measurement model is found to be acceptable, then to proceed to the second step of testing the structural model. Therefore, before testing the full model, confirmatory factor analysis was carried out on the questionnaire items to confirm its factorial structure. Specifically, CFA was used to determine the extent to which the items used to measure the specific factors actually did so (Byrne, 1994).

*Testing for invariance of the measurement model across sex.* Once the measurement model was confirmed for the full sample, a test for invariance was conducted to examine the extent to which the measuring instrument (i.e., questionnaire) operated equivalently across sexes. Specifically, the test for invariance was conducted to answer the following questions: (a) Do the items comprising the questionnaire operate equivalently across sex, and (b) is the factorial structure of the questionnaire equivalent across sex?

*Testing for invariance of the measurement model across persistence.* Once the measurement model was confirmed for the full sample as well as across sex, a test for invariance was conducted to examine the extent to which the measuring instrument (i.e., questionnaire) operated equivalently for persisters and resisters. Specifically, the test for invariance was conducted to answer the following questions: (a) Do the items comprising the questionnaire operate equivalently across persisters and resisters, and (b) is the factorial structure of the questionnaire equivalent across persisters and resisters?

*Testing the validity of the structural model.* Once the factorial structure of the questionnaire was confirmed, the full latent variable model was tested to evaluate how well the proposed relationships between latent variables represented the data. The full structural model (i.e., latent variable model) was tested in three steps. First, the model was tested for the full sample. Second, the model was tested separately for the samples of males and females in order to examine structural differences in the best-fitting models for males and females. Third, the model was tested separately for the samples of persisters and resisters in order to examine structural differences in the best-fitting models for persisters and resisters. Invariance tests were also conducted to examine differences in the magnitudes of path coefficients between the best-fitting models for males and females, and differences in the magnitudes of path coefficients between the best-fitting models for persisters and resisters.

The possibility of testing separate models for the samples of female persisters, female resisters, male persisters, and male resisters was considered. These models could hold important clues in understanding how males and females come to make decisions regarding persistence in science. However, given the relatively small sample of female resisters ($N = 193$) and male resisters ($N = 138$), the results obtained from SEM would not be reliable and therefore these models could not be tested. According to Byrne (2001), a sample of at least 200 participants is necessary in order to obtain reliable results with SEM.

# Chapter 4

## *Results*

### *Correlations and Mean Differences*

Correlations among all variables are presented in Table 3. Interestingly, contrary to expectation, the performance goal orientation and intrinsic motivation were positively rather than negatively correlated, indicating that students who were performance-oriented also tended to be intrinsically motivated. However, this correlation was relatively small (.13), indicating that the relationship between a performance-goal orientation and intrinsic motivation is fairly weak. The strongest correlation (.60) was between intrinsic motivation and the mastery-goal orientation, indicating that students who were mastery oriented were also highly intrinsically motivated, a result that was expected given prior research. Overall, all variables tended to be significantly correlated with one another except for the avoidance-goal orientation variable that was not significantly correlated with autonomy, relatedness, intrinsic motivation, or mastery-goal orientation. In addition, perceptions of relatedness and self-efficacy were not correlated, nor were perceptions of autonomy and performance-goal orientation. The magnitude of the significant correlations varied from small (.06) to large (.60; Cohen, 1988).

A MANOVA was performed to test for the presence of sex differences between men and women on the variables measured. This analysis revealed a multivariate significant effect, $F(1,1307) = 15.63, p < .0001$. Results of this analysis are presented in Table 4.

Table 3
*Correlations Among all Variables*

| Measures | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. Autonomy-support | - | | | | | | | | | |
| 2. Relatedness | .50** | - | | | | | | | | |
| 3. Self-Efficacy | .22** | .03 | - | | | | | | | |
| 4. Intrinsic motivation | .29** | .19** | .21** | - | | | | | | |
| 5. Positive affect | .37** | .22** | .41** | .31** | - | | | | | |
| 6. Negative affect | -.28** | -.18** | -.50** | -.08** | -.41** | - | | | | |
| 7. Mastery goal | .37** | .26** | .33** | .60** | .42** | -.20** | - | | | |
| 8. Performance goal | -.01 | -.06* | .17** | .13** | .10** | .06* | .08** | - | | |
| 9. Avoidance goal | -.04 | .03 | -.14** | -.01 | -.06* | .23** | -.05 | .40** | - | |
| 10. Achievement | .16** | -.02 | .30** | .16** | .16** | -.15** | .15** | .12** | -.08 | - |

NOTE: *$p < .05$. **$p < .01$.

The multivariate $F$ test revealed significant ($p < .001$) sex differences in self-efficacy and negative affect, with women feeling significantly less self-efficacious and experiencing significantly more negative affect than men. The size of the effects for self-efficacy (.55) and negative affect (.32) were moderate. More modest sex differences ($p < .05$) were found for intrinsic motivation, mastery- and avoidance-goal orientation, with women feeling more intrinsically motivated and mastery oriented, but adopting more avoidance goals than men. The effect sizes for these differences were small (below .20).

Table 4
*Variable Means and Standard Deviations as a Function of Sex*

| | Females | | Males | | |
|---|---|---|---|---|---|
| Measures | *M* | *SD* | *M* | *SD* | |
| 1. Autonomy-support | 3.51 | .66 | 3.49 | .67 | |
| 2. Relatedness | 3.14 | .66 | 3.09 | .65 | |
| 3. Self-Efficacy | 3.32 | .55 | 3.63*** | .57 | (.55) |
| 4. Intrinsic motivation | 3.83 | .60 | 3.75* | .60 | (.13) |
| 5. Positive affect | 3.14 | .77 | 3.18 | .76 | |
| 6. Negative affect | 2.47 | .77 | 2.24*** | .68 | (.32) |
| 7. Mastery goal | 3.74 | .48 | 3.69* | .55 | (.10) |
| 8. Performance goal | 3.30 | .62 | 3.34 | .62 | |
| 9. Avoidance goal | 2.81 | .59 | 2.74* | .56 | (.12) |
| 10. Achievement | 81.50 | 7.08 | 81.39 | 7.07 | |

NOTE: *$p < .05$. **$p < .01$. ***$p < .001$.
Effect sizes are noted in parentheses and calculated using Cohen's $d$

A MANOVA was also performed to test for the presence of mean differences between persisters and resisters on the variables measured. This analysis revealed a multivariate significant effect, $F(1,1307) = 23.51, p < .0001$. As can be seen in Table 5, persisters and resisters differed significantly on most of the variables. Persisters felt significantly more autonomous in their high school mathematics and science courses, more related, more self-efficacious, more intrinsically motivated, experienced more positive affect and less negative affect, and were more mastery- and performance-goal oriented than resisters. Persisters also had significantly higher grades in high school mathematics and science courses than resisters, even though resisters had sufficient grades to be admitted to a science program. Effect sizes ranged from small (performance goal, .19) to large (achievement, .89), with most effect sizes being in the small to moderate range.

Table 5
*Variable Means and Standard Deviations as a Function of Persistence*

| | Persisters | | Resisters | | |
|---|---|---|---|---|---|
| Measures | *M* | *SD* | *M* | *SD* | |
| 1. Autonomy-support | 3.57 | .64 | 3.31*** | .70 | (.34) |
| 2. Relatedness | 3.15 | .64 | 3.02** | .68 | (.20) |
| 3. Self-Efficacy | 3.52 | .56 | 3.31*** | .59 | (.37) |
| 4. Intrinsic motivation | 3.84 | .58 | 3.67*** | .65 | (.28) |
| 5. Positive affect | 3.25 | .74 | 2.89*** | .78 | (.47) |
| 6. Negative affect | 2.29 | .69 | 2.56*** | .82 | (.36) |
| 7. Mastery goal | 3.76 | .50 | 3.59*** | .52 | (.33) |
| 8. Performance goal | 3.35 | .62 | 3.23** | .63 | (.19) |
| 9. Avoidance goal | 2.76 | .58 | 2.81 | .55 | |
| 10. Achievement | 82.87 | 6.92 | 77.22*** | 5.68 | (.89) |

NOTE: $*p < .05$. $**p < .01$. $***p < .001$.
Effect sizes are noted in parentheses and calculated using Cohen's *d*

As can be seen in the above tables, differences between men and women were quite small in comparison to the differences between persisters and resisters. The sample was therefore broken down to examine sex differences between persisters and resisters. Tables 6 and 7 depict mean differences on the variables as a function of persistence for males and females. As can be seen in Table 6, female persisters as opposed to female resisters felt significantly more autonomous, more self-efficacious, and more intrinsically motivated, experienced more positive affect and less negative affect, and were more mastery- and performance-oriented. They also had significantly higher grades than resisters. Effect sizes ranged from small (intrinsic motivation, .18) to large (achievement, .87), with most effect sizes being in the small to moderate range.

Table 6
*Variable Means and Standard Deviations as a Function of Persistence for Females*

| | Female Persisters | | Female Resisters | | |
|---|---|---|---|---|---|
| Measures | *M* | *SD* | *M* | *SD* | |
| 1. Autonomy-support | 3.57 | .63 | 3.36*** | .73 | (.31) |
| 2. Relatedness | 3.16 | .64 | 3.07 | .71 | |
| 3. Self-Efficacy | 3.37 | .53 | 3.21*** | .59 | (.26) |
| 4. Intrinsic motivation | 3.86 | .59 | 3.75* | .65 | (.18) |
| 5. Positive affect | 3.23 | .73 | 2.90*** | .81 | (.43) |
| 6. Negative affect | 2.38 | .71 | 2.69*** | .87 | (.39) |
| 7. Mastery goal | 3.79 | .47 | 3.64*** | .50 | (.31) |
| 8. Performance goal | 3.34 | .62 | 3.20** | .64 | (.22) |
| 9. Avoidance goal | 2.80 | .59 | 2.84 | .59 | |
| 10. Achievement | 83.02 | 6.86 | 77.43*** | 5.96 | (.87) |

NOTE: *$p < .05$. **$p < .01$. ***$p < .001$.
Effect sizes are noted in parentheses and calculated using Cohen's *d*

As can be seen in Table 7, male persisters, as opposed to male resisters, felt more autonomous and related, more self-efficacious, more intrinsically motivated, experienced more positive affect and less negative affect, and were more mastery-oriented. They also had significantly higher grades than resisters. Effect sizes ranged from small (negative affect, .26) to large (achievement, .92), with most effect sizes being in moderate range.

Table 7
*Variable Means and Standard Deviations as a Function of Persistence for Males*

| Measures | Male Persisters | | Male Resisters | | |
|---|---|---|---|---|---|
| | *M* | *SD* | *M* | *SD* | |
| 1. Autonomy-support | 3.56 | .66 | 3.26*** | .65 | (.46) |
| 2. Relatedness | 3.13 | .65 | 2.95** | .62 | (.29) |
| 3. Self-Efficacy | 3.68 | .56 | 3.45*** | .56 | (.41) |
| 4. Intrinsic motivation | 3.81 | .57 | 3.55*** | .64 | (.43) |
| 5. Positive affect | 3.27 | .74 | 2.87*** | .75 | (.54) |
| 6. Negative affect | 2.20 | .67 | 2.38** | .72 | (.26) |
| 7. Mastery goal | 3.74 | .54 | 3.52*** | .55 | (.40) |
| 8. Performance goal | 3.36 | .62 | 3.27 | .62 | |
| 9. Avoidance goal | 2.73 | .57 | 2.78 | .51 | |
| 10. Achievement | 82.71 | 7.00 | 76.94*** | 5.28 | (.92) |

NOTE: $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.
Effect sizes are noted in parentheses and calculated using Cohen's *d*

The sample was again broken down to examine sex differences between persisters and sex differences between resisters. Tables 8 and 9 depict mean differences across the variables as a function of sex for persisters and resisters. As can be seen in Table 8, female persisters, as opposed to male persisters, had significantly lower self-efficacy and higher negative affect, thus reproducing the pattern obtained when men and women were compared irrespective of whether they were persisters or resisters. The effect size for self-efficacy was moderate (.57) while the effect size for negative affect was small (.26).

As can be seen in Table 9, female resisters, as opposed to male resisters, had significantly lower self-efficacy and higher negative affect. The effect sizes for these differences were moderate (self-efficacy, .42; negative affect, .39). In addition, female resisters were significantly more intrinsically motivated and mastery-goal oriented than male resisters. The effect sizes for these differences were small (intrinsic motivation, .31; mastery goal, .23).

Table 8
*Variable Means and Standard Deviations as a Function of Sex for Persisters*

| | Male Persisters | | Female Persisters | | |
|---|---|---|---|---|---|
| Measures | *M* | *SD* | *M* | *SD* | |
| 1. Autonomy-support | 3.56 | .66 | 3.57 | .62 | |
| 2. Relatedness | 3.13 | .65 | 3.16 | .64 | |
| 3. Self-Efficacy | 3.68 | .56 | 3.37*** | .53 | (.57) |
| 4. Intrinsic motivation | 3.81 | .57 | 3.86 | .59 | |
| 5. Positive affect | 3.27 | .74 | 3.23 | .73 | |
| 6. Negative affect | 2.20 | .67 | 2.38*** | .71 | (.26) |
| 7. Mastery goal | 3.74 | .54 | 3.79 | .47 | |
| 8. Performance goal | 3.36 | .62 | 3.34 | .62 | |
| 9. Avoidance goal | 2.73 | .57 | 2.80 | .58 | |
| 10. Achievement | 82.71 | 7.00 | 83.02 | 6.86 | |

NOTE: *$p < .05$. **$p < .01$. ***$p < .001$.
Effect sizes are noted in parentheses and calculated using Cohen's *d*

Table 9
*Variable Means and Standard Deviations as a Function of Sex for Resisters*

| | Male Resisters | | Female Resisters | | |
|---|---|---|---|---|---|
| Measures | *M* | *SD* | *M* | *SD* | |
| 1. Autonomy-support | 3.26 | .65 | 3.36 | .73 | |
| 2. Relatedness | 2.95 | .62 | 3.07 | .71 | |
| 3. Self-Efficacy | 3.45 | .56 | 3.21*** | .59 | (.42) |
| 4. Intrinsic motivation | 3.55 | .64 | 3.75** | .65 | (.31) |
| 5. Positive affect | 2.87 | .75 | 2.90 | .81 | |
| 6. Negative affect | 2.38 | .72 | 2.69*** | .87 | (.39) |
| 7. Mastery goal | 3.52 | .55 | 3.64* | .50 | (.23) |
| 8. Performance goal | 3.27 | .62 | 3.20 | .64 | |
| 9. Avoidance goal | 2.78 | .51 | 2.84 | .59 | |
| 10. Achievement | 76.94 | 5.28 | 77.43 | 5.96 | |

NOTE: *$p < .05$. **$p < .01$. ***$p < .001$.
Effect sizes are noted in parentheses and calculated using Cohen's *d*

*Variables in SEM*

Before carrying out the structural equation modeling, it was decided that some variables that were measured would not be included in the model. This was done because of the relatively small sample size that would result when the model was broken down to compare men versus women and persisters versus resisters. When conducting SEM with a large number of variables, even if one finds a fit to the model, this fit is probably unreliable because of the small sample size (Green, 1991). In other words, large numbers of variables can lead to a good model fit despite a small sample size. In order to ensure a ratio of at least 10 participants per parameter estimated, two variables were not included in the model. The avoidance-goal orientation was not included because it was not significantly correlated with many of the other variables (see Table 3) and because the mean of the avoidance-goal variable was not significantly different for persisters versus resisters (see Table 5), female persisters versus female resisters (see Table 6) or male persisters versus male resisters (see Table 7) and would therefore not likely explain differences between these groups. In addition, all prior research on achievement goals has found that avoidance goals have a detrimental effect on motivation, achievement and persistence and so including this variable in the model would not likely add any new information (Linnenbrink, 2005).

It was also decided that the relatedness variable would not be included in the model. A preliminary confirmatory factor analysis (CFA) using only the variables directly related to self-determination theory revealed that relatedness was not related to either self-efficacy or intrinsic motivation. The model tested is presented in Figure 4 below.

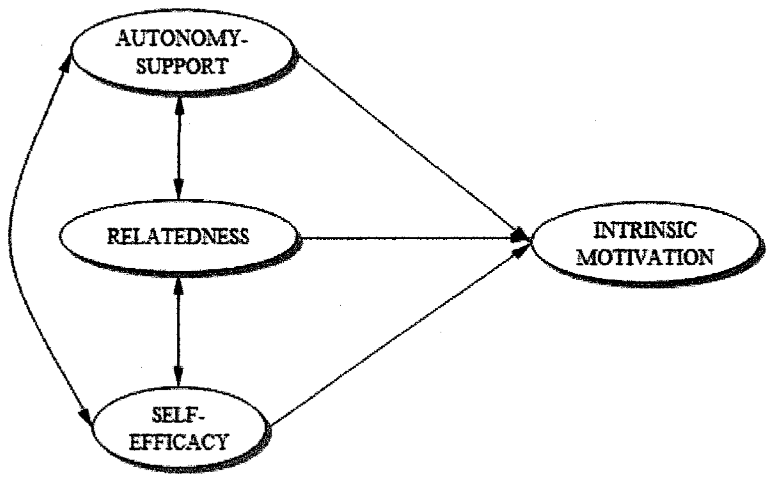


*Figure 4*. Self-determination model.

The model yielded the following results: $\chi^2\,(21) = 87.57, p < .0001$, $\chi^2/df = 4.17$, CFI = .972, NNFI = .952, and RMSEA = .049. Two of the paths were not significant and results of the Wald test suggested that these paths should be removed to improve model fit (i.e., the covariance between relatedness and self-efficacy and between relatedness and intrinsic motivation). Dropping these two covariances and re-running the model yielded the following results: $\chi^2\,(23) = 91.00, p < .0001$, $\chi^2/df = 3.95$, CFI = .972, NNFI = .955, RMSEA = .048. Because the relatedness variable was not related to intrinsic motivation as hypothesized, and because prior research has suggested that relatedness plays a more distal role than autonomy-support and competence, it was omitted from the model.

*Structural Equation Modeling Analyses*

The adequacy of the fit of the model was assessed by structural equation modeling with the EQS program (Version 6.1 for Windows). As can be seen in Figure 3, the proposed model contained four independent variables (i.e., autonomy-support, self-efficacy, mastery goal orientation, and performance goal orientation), four mediating variables (i.e., intrinsic motivation, positive affect, negative affect, and achievement), and one dependent variable (i.e., persistence).

There were originally 28 observed variables (i.e., questionnaire items) to be included in the model. When the sample size is not particularly large compared to the number of variables and when the variables are not normally distributed, it has been suggested that the number of indicators per latent factors should be reduced by creating item pairs (Marsh, Richards, Johnson, Roche, & Tremayne, 1994; Vallerand, 1997). All factor analyses were therefore conducted on item-pair responses. Pairs of items were created by taking the mean of the first two items in each subscale, the mean of the second two items, and so forth. Marsh et al. (1994) recommend this method because item-pair scores are more reliable, reduce the variance of the variables and tend to be more normally distributed, and because the ratio of the number of measured variables to the number of participants is halved (Ntoumanis, 2001). The only variable for which item pairs were not created was intrinsic motivation, which only contained two items to begin with, and when using SEM, in order to be able to account for measurement error, each latent factor must be made up of at least two items.

A covariance matrix with the 15 resulting observed variables (13 item pairs and two individual intrinsic motivation items) was used as a database for the measurement model. For the structural model, a correlation matrix with the 15 observed variables was used because one of the dependent variables (i.e. persistence) is a dichotomous variable (1 = enrolled in science; 2 = not enrolled in science). The specification *CATEGORY = PERSISTENCE* was used so that the dichotomous variable could be included in the model. This specification is described in the EQS manual (Bentler, 1995).

The specified model was tested with standardized coefficients obtained from the robust maximum likelihood (RML) method of estimation. The robust method was used because Mardia's coefficient indicated large multivariate kurtosis (around 20). This analysis is recommended by Bentler (1995) when the data are not normally distributed. When the distributional assumption underlying the maximum likelihood method is not met, the robust statistics are more trustworthy than the ordinary statistics (Chou et al., 1991).

*Plan for Reporting Results of SEM*

The results of SEM are presented in the following manner. First, the measurement model was tested (i.e., first-order confirmatory factor analysis) to examine whether the questionnaire items load onto the factor (i.e., variable) they were designed to measure. Once the measurement model was confirmed for the full sample, separate measurement models were tested for (a) males and females, and (b) persisters and resisters. This was done in order to examine whether the questionnaire operates similarly for these different sub-groups (i.e., whether these groups have the same first-order factors). Next, the structural model was tested (i.e., second-order confirmatory factor analysis) to examine whether the factors related to one another as hypothesized in the model. Once the structural model was confirmed for the full sample, separate structural models were tested for the different groups mentioned above to examine whether the model operates similarly for these groups. Finally, tests for model invariance were conducted to compare and examine differences between path coefficients in the resulting models for males vs females and persisters vs resisters.

*Measurement Model (First-Order CFA)*

Before testing the full model, confirmatory factor analysis using EQS was carried out to test hypotheses related to the factorial structure of the questionnaire. This was done to confirm that the items designed to measure a particular variable (i.e., factor) actually did so. The CFA model hypothesized that (a) responses to the questionnaire could be explained by seven factors, (b) each item would have a nonzero loading on the variable it was designed to measure and zero loadings on all other variables, (c) the seven factors would be correlated (except for autonomy-support and performance goal orientation, see Table 3), and (d) measurement error terms would be uncorrelated.

*Full sample.* A schematic representation of this model is presented in Figure 5. Although the chi square value was significant ($\chi^2(69) = 333.64, p < .0001, \chi^2/df = 4.83$), the CFI value of .952, NNFI value of .927, and RMSEA value of .054 indicated a good fit to the data. Results of the Wald test suggested dropping one factor covariance (F4,F1, the covariance between autonomy-support and performance goal orientation, as expected, see Table 3). Dropping this covariance and re-running the model yielded the following results: $\chi^2(70) = 333.02, p < .0001, \chi^2/df = 4.76$, CFI = .953, NNFI = .929, RMSEA = .054 (for purposes of clarity, only covariances between adjacent factors are included in the figure).

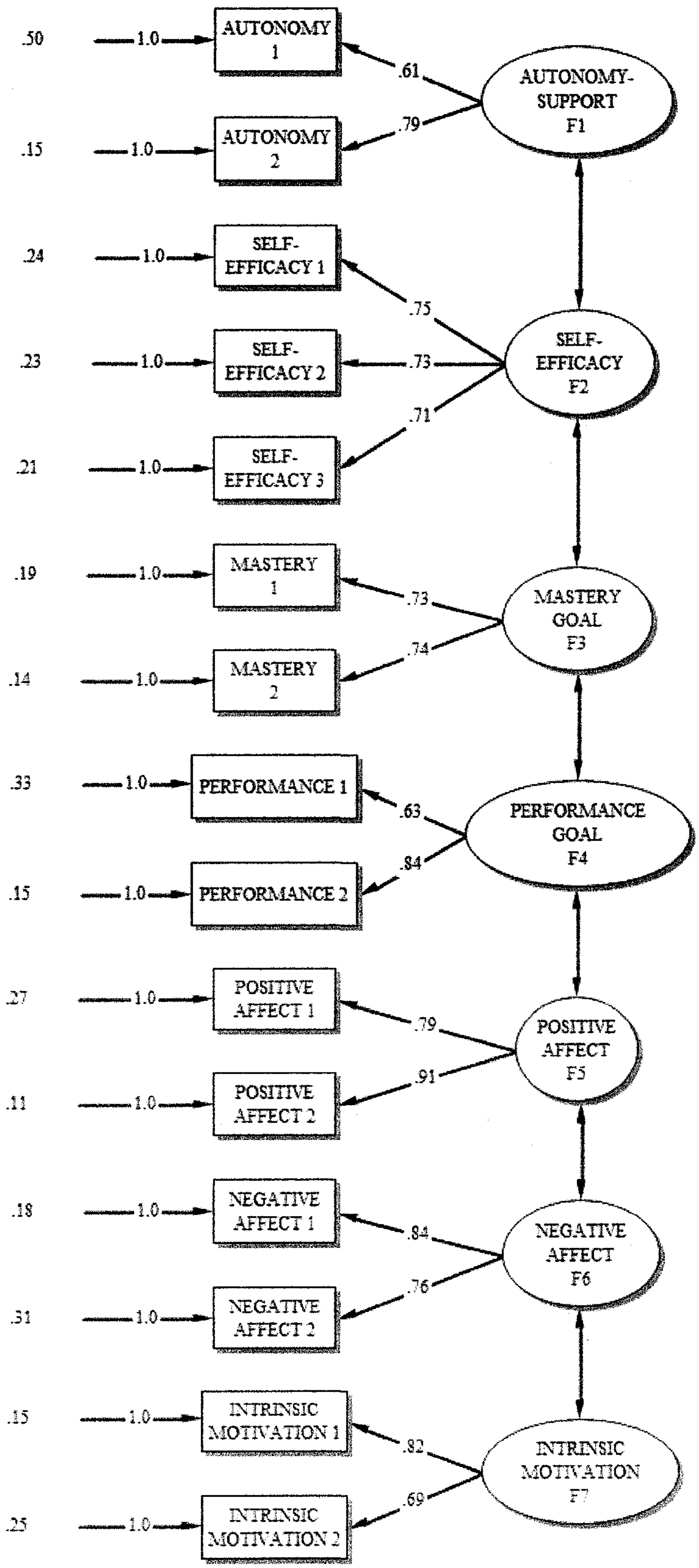


*Figure 5*. Seven factor full measurement model.

*Men and women.* Once the measurement model was confirmed for the full sample, two measurement models were tested separately, one for each sex, to examine whether the measuring instrument (i.e., questionnaire) operated similarly for both men and women. For men, the measurement model yielded the following results: $\chi^2$ (70) = 195.56, $p < .0001$, $\chi^2$/df = 2.79, CFI = .947, NNFI = .920, RMSEA = .055, indicating satisfactory model fit. Results of the Wald test suggested dropping two factor covariances (F6,F4 and F7,F6). Dropping these covariances and re-running the model yielded the following results: $\chi^2$ (72) = 201.58, $p < .0001$, $\chi^2$/df = 2.80, CFI = .946, NNFI = .920, RMSEA = .055. For women, the originally hypothesized measurement model yielded the following results: $\chi^2$ (70) = 240.14, $p < .0001$, $\chi^2$/df = 3.43, CFI = .946, NNFI = .920, RMSEA = .057, indicating satisfactory model fit. Results of the Wald test suggested dropping two factor covariances (F4,F3 and F5,F4). Dropping these covariances and re-running the model yielded the following results: $\chi^2$ (72) = 242.18, $p < .0001$, $\chi^2$/df = 3.36, CFI = .946, NNFI = .922, RMSEA = .055. As can be seen by the results presented above, dropping the covariances did not lead to any significant improvement in model fit. It is not recommended to drop covariances as a result of the Wald test unless the researcher has a compelling theoretical reason to do so (Kim & Bentler, 2006). Therefore, although the Wald test suggested changes, since the improvement in the model fit was minimal and since there was no *a priori* theoretical reason for implementing the changes in the model, the original models were used without removing the covariances. A schematic representation of the CFA measurement models for men and women is presented in Figure 6 below.

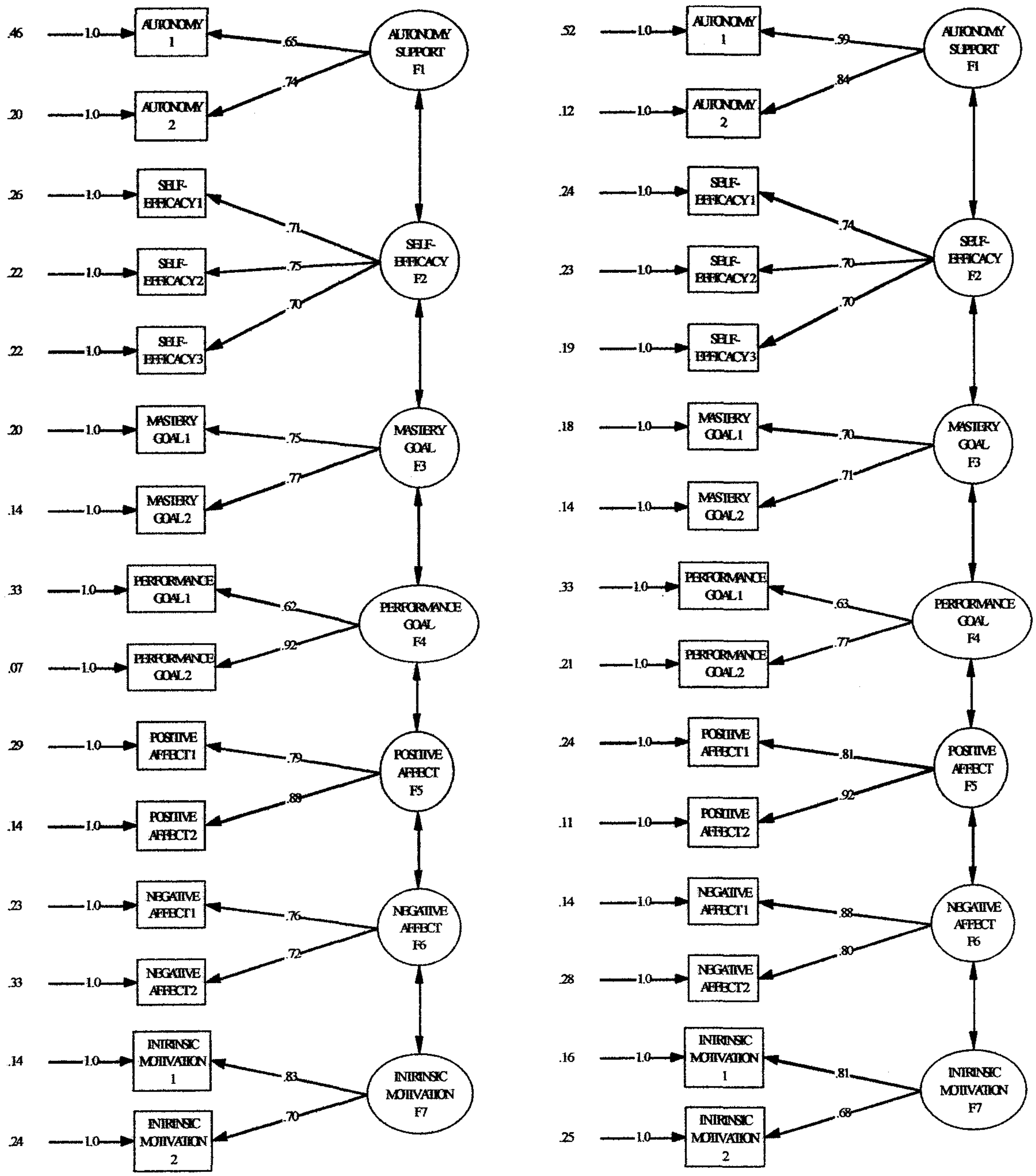


*Figure 6*. Full measurement model for men (left) and women (right).

Once the measurement models were confirmed for both men and women, a test for invariance across sex was conducted to test for equivalency of the factorial structure (i.e., scale items) of the questionnaire across men and women (Byrne, 2001). A series of equality constraints were specified to test whether the questionnaire items loaded on their respective factors in an identical manner for men and women. As indicated by a CFI of .952, NNFI of .931, $\chi^2(148) = 437.80$, $p < .0001$, and $\chi^2/df = 2.96$, the results for this test of the measurement model indicated a fairly good fit to the data. The validity of the imposed equality constraints (i.e., all paths that existed for both sexes) was examined using both univariate and multivariate tests. In EQS, one simply has to check the probability values associated with the LM $\chi^2$ (i.e., Lagrange multiplier chi-square) to determine if any of the tests was statistically significant. In the present case, all probability values were greater than .05, indicating that the hypothesized equality of the factor loadings held. We can therefore conclude that the measurement model is completely invariant across sex.

Next, a test for the equality of the factor variances and covariances was conducted, while concomitantly constraining all invariant item measurements. Equality constraints were imposed for all factor variances and covariances that were found to exist for both men and women. Results yielded a CFI of .945, NNFI of .934, $\chi^2(175) = 479.66$, $p < .0001$, and $\chi^2/df = 2.74$. Examination of the probability values associated with the univariate and multivariate LM $\chi^2$ test statistic revealed that one of the constraints was non-invariant across groups (i.e., the factor covariance between self-efficacy and autonomy, $p = .048$). As a follow up to this result, a second test of invariance was conducted in which this constraint was released. Results yielded a CFI of .948, NNFI of .937, $\chi^2(174) = 475.36$, $p < .0001$, and $\chi^2/df = 2.73$, indicating a slightly improved fit. The resulting measurement model is fully invariant across sex.

*Persisters and resisters.* Two measurement models were tested separately, one for persisters and one for resisters, to examine whether the measuring instrument (i.e., questionnaire) operated similarly for these two groups. For persisters, the measurement model yielded the following results: $\chi^2$ (70) = 259.39, $p < .0001$, $\chi^2$/df = 3.70, CFI = .950, NNFI = .925, RMSEA = .053, indicating satisfactory model fit. For resisters, the originally hypothesized measurement model yielded the following results: $\chi^2$ (72) = 147.96, $p < .0001$, $\chi^2$/df = 2.05, CFI = .950, NNFI = .927, RMSEA = .057. A schematic representation of the CFA measurement models for persisters and resisters is presented in Figure 7.

Once the measurement models were confirmed for both persisters and resisters, a test for invariance was conducted to test for equivalency of the factorial structure (i.e., scale items) of the questionnaire across these two groups (Byrne, 2001). A series of equality constraints were specified to test whether the questionnaire items loaded on their respective factors in an identical manner for persisters and resisters. As indicated by a CFI of .951, NNFI of .931, $\chi^2$ (150) = 419.04, $p < .0001$, and $\chi^2$/df = 2.79, the results for this test of the measurement model indicated a fairly good fit to the data. The validity of the imposed equality constraints was examined using both univariate and multivariate tests. In EQS, one simply has to check the probability values associated with the LM $\chi^2$ (Lagrange multiplier chi-square) to determine if any of the tests was statistically significant. In the present case, all probability values were greater than .05, indicating that the hypothesized equality of the factor loadings held. We can therefore conclude that the measurement model is fully invariant across persisters and resisters.

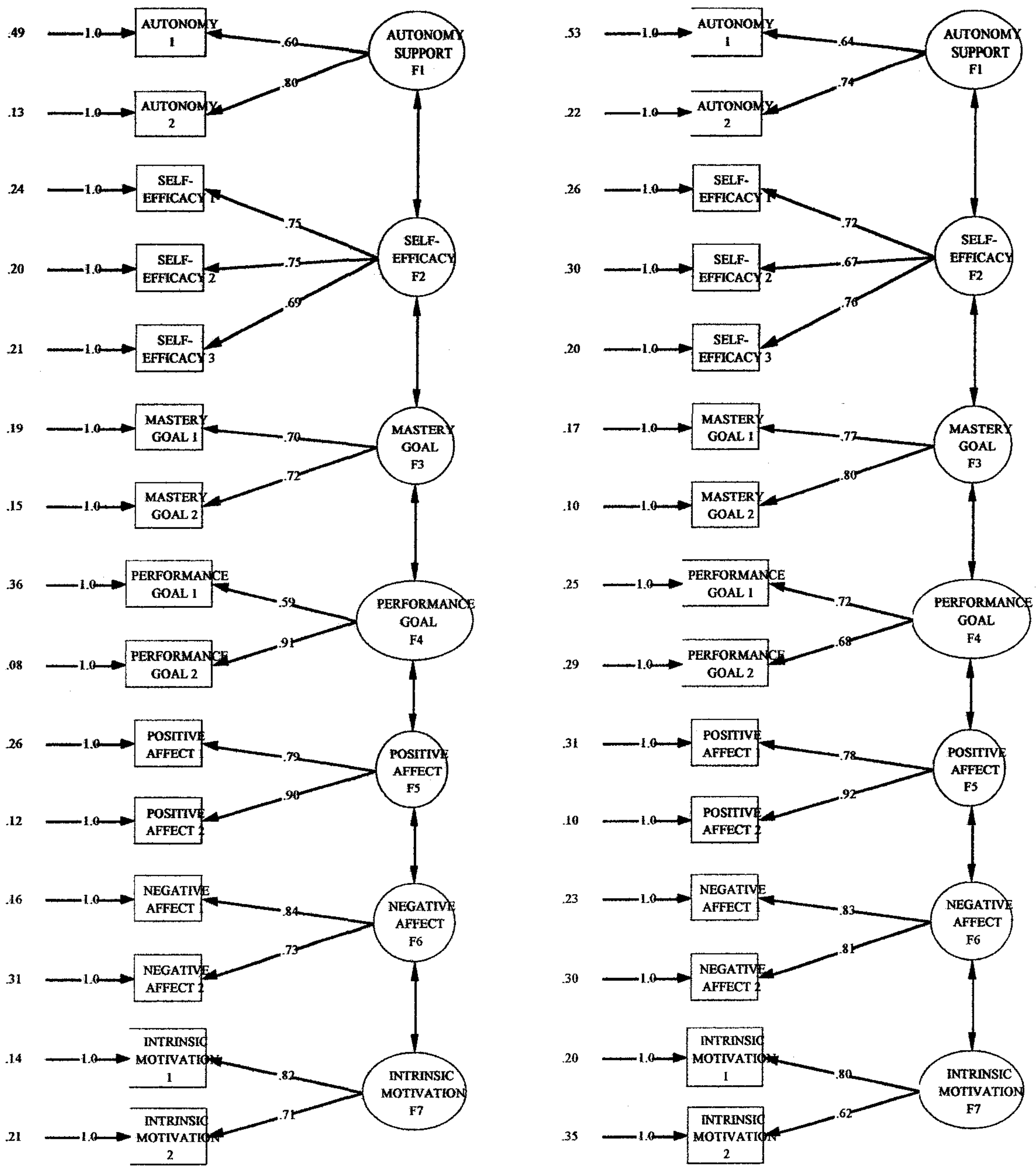


*Figure 7.* Full measurement model for persisters (left) and resisters (right).

Next, a test for the equality of the factor variances and covariances was conducted, while concomitantly constraining all invariant item measurements. Equality constraints were imposed for all factor variances and covariances that were found to exist for both persisters and resisters. Results yielded a CFI of .950, NNFI of .940, $\chi^2$ (175) =

447.97, $p < .0001$, and $\chi^2$/df = 2.56. Examination of the probability values associated with the univariate and multivariate LM $\chi^2$ test statistic revealed that two of the constraints were non-invariant across groups (i.e., the factor covariances between positive affect and intrinsic motivation, and between self-efficacy and performance-goal orientation). As a follow up to this result, a second test of invariance was conducted in which these two constraints were released. Results yielded a CFI of .952, NNFI of .941, $\chi^2$ (173) = 435.19, $p < .0001$, and $\chi^2$/df = 2.51, indicating a slightly improved fit. The resulting measurement model is fully invariant across persisters and resisters. We now proceeded to examine the structural model.

*Structural Model (Second-Order CFA)*

The structural model that was tested is presented in Figure 8 below.

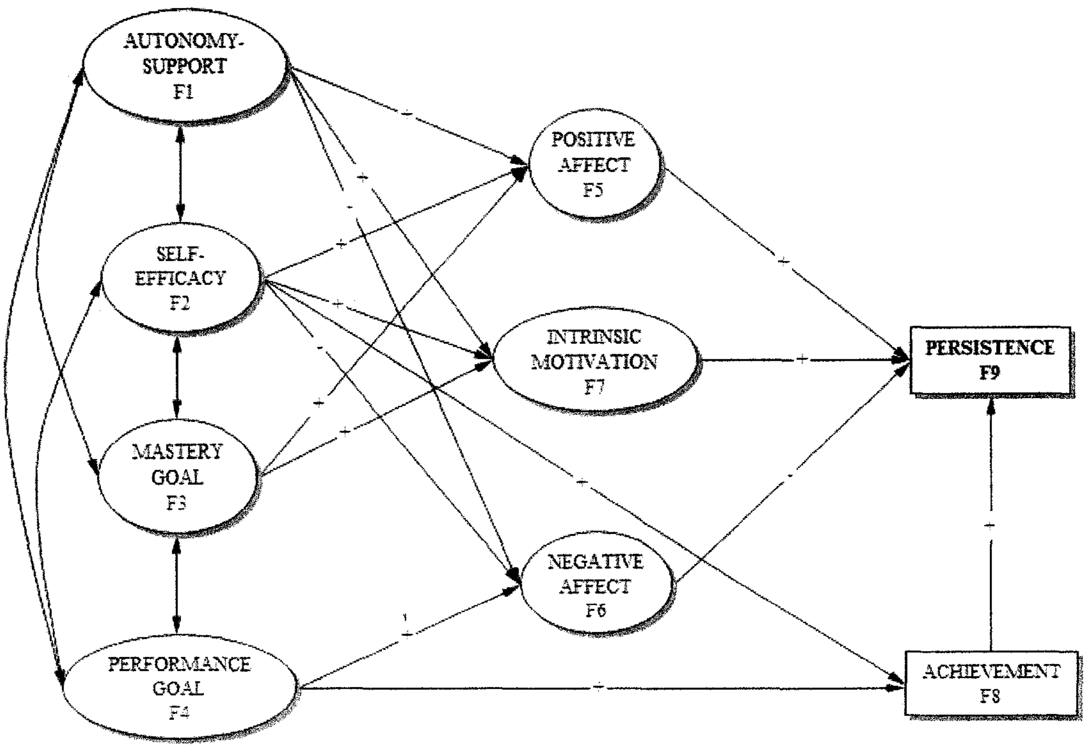


*Figure 8*. Hypothesized full structural model.

*Full sample.* The overall fit of this model was satisfactory and yielded the following results: $\chi^2$ (101) = 467.52, $p < .001$, $\chi^2$/df = 4.63, CFI = .940, NNFI = .918, and RMSEA = .053. Results of the Wald test indicated that three parameters were non significant (F7,F1, F9,F7, and F9,F6). Re-running the model without the three non significant paths yielded the following results: $\chi^2$ (104) = 469.86, $p < .001$, $\chi^2$/df = 4.52, CFI = .940, NNFI = .920, and RMSEA = .052 (see Figure 9).

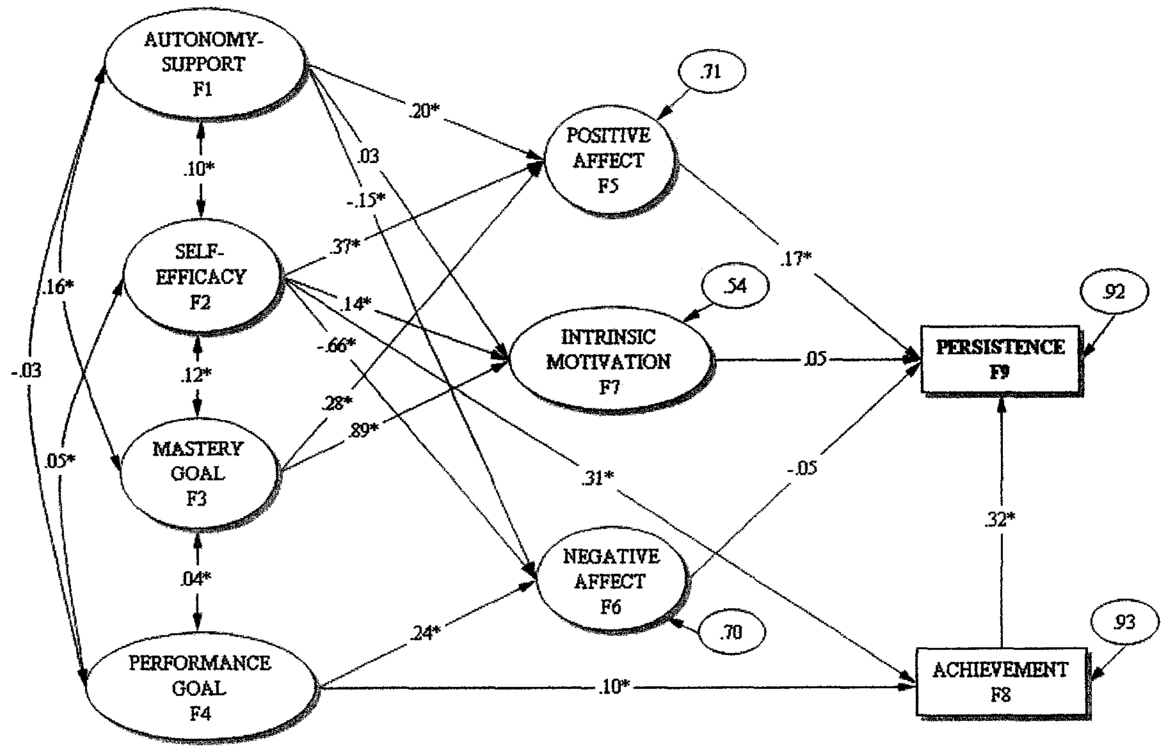


*Figure 9.* Final full structural model.

Since the model fit was satisfactory, the path coefficients were examined using the standardized parameter estimates. Contrary to expectations, the association between autonomy-support and intrinsic motivation was not significant ($\beta = .03, p > .05$). Hypothesis 1a was therefore not supported. The association between autonomy-support and positive affect was positive and significant ($\beta = .20, p < .05$) and the association between autonomy-support and negative affect was negative and significant ($\beta = -.15, p < .05$). Hypotheses 1b and 1c were therefore supported.

The association between self-efficacy and intrinsic motivation was positive and significant ($\beta = .14, p < .05$), the association between self-efficacy and positive affect was positive and significant ($\beta = .37, p < .05$), and the association between self-efficacy and negative affect was negative and significant ($\beta = -.66, p < .05$). Hypotheses 2a, 2b, and 2c were therefore supported. The association between self-efficacy and achievement was positive and significant ($\beta = .31, p < .05$). Hypothesis 2d was therefore supported.

The association between a mastery-goal orientation and intrinsic motivation was positive and significant ($\beta = .89, p < .05$), and the association between a mastery-goal orientation and positive affect was positive and significant ($\beta = .28, p < .05$). Hypotheses 3a and 3b were therefore supported. The association between a performance goal orientation and negative affect was positive and significant ($\beta = .24, p < .05$) and the association between a performance-goal orientation and achievement was also positive and significant ($\beta = .10, p < .05$). Hypotheses 3c and 3d were therefore supported.

The association between positive affect and persistence was positive and significant ($\beta = .17, p < .05$) while the association between negative affect and persistence was non-significant ($\beta = -.05, p > .05$). Therefore hypothesis 4a was supported while hypothesis 4b was not. The association between intrinsic motivation and persistence was not significant ($\beta = .05, p > .05$) so hypothesis 5 was not supported.

Finally, the association between achievement and persistence was positive and significant ($\beta = .32$, $p < .05$) therefore hypothesis 6 was supported.

*Men and women.* Since the model was confirmed for the full sample, it was re-run separately for the samples of women and men. For women, the model fit was satisfactory and yielded the following results: $\chi^2$ (104) = 347.20, $p < .001$, $\chi^2$/df = 3.34, CFI = .930, NNFI = .907, and RMSEA = .058. The Wald test indicated that three parameters were non significant (F4,F3, F5,F1, and F6,F1). Re-running the model without the three non significant paths yielded the following results: $\chi^2$ (107) = 354.16, $p < .0001$, $\chi^2$/df = 3.31, CFI = .929, NNFI = .908, and RMSEA = .057. The model for women is presented in Figure 10.

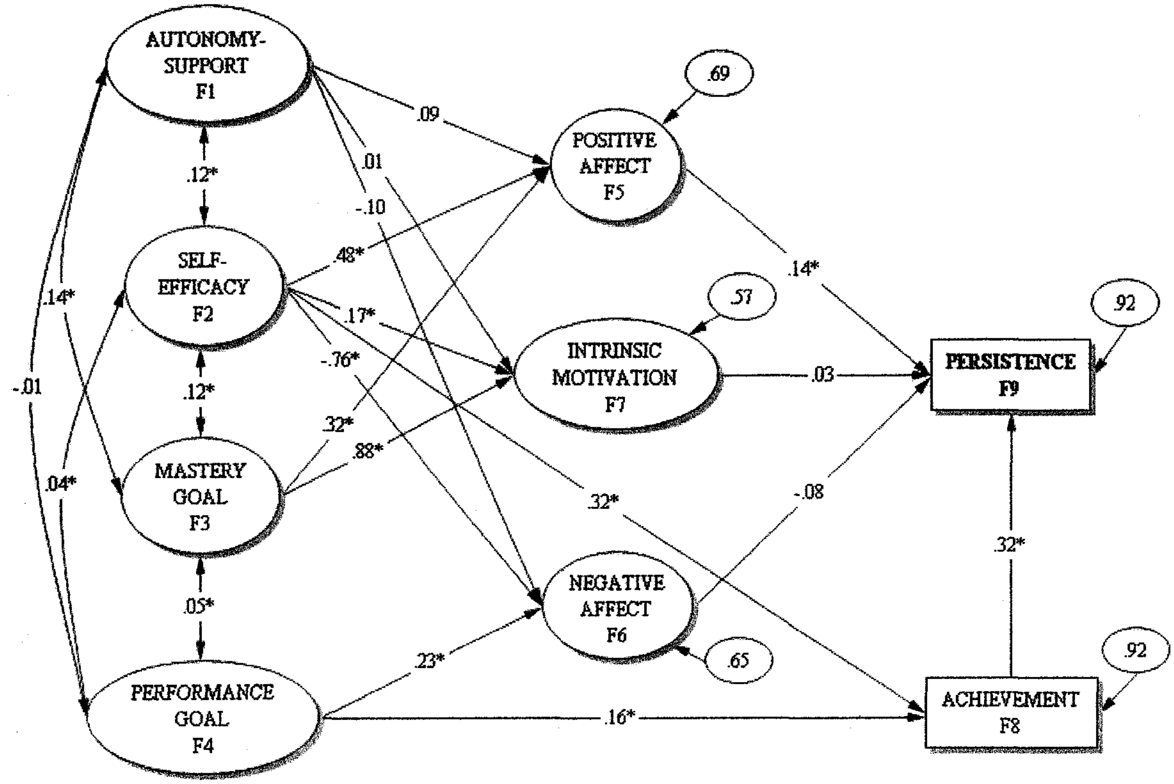


*Figure 10.* Model for women.

For men, the model fit was satisfactory and yielded the following results: $\chi^2$ (104) = 256.43, $p < .001$, $\chi^2$/df = 2.47, CFI = .942, NNFI = .923, and RMSEA = .049. The Wald test indicated that one parameter was non significant (F8,F4). Re-running the model without the non significant path yielded the following results: $\chi^2$ (105) = 256.62, $p < .001$, $\chi^2$/df = 2.44, CFI = .942, NNFI = .924, and RMSEA = .049. The model for men is presented in Figure 11. Comparisons between the models for men and women are discussed below, after the models for persisters and resisters are presented.

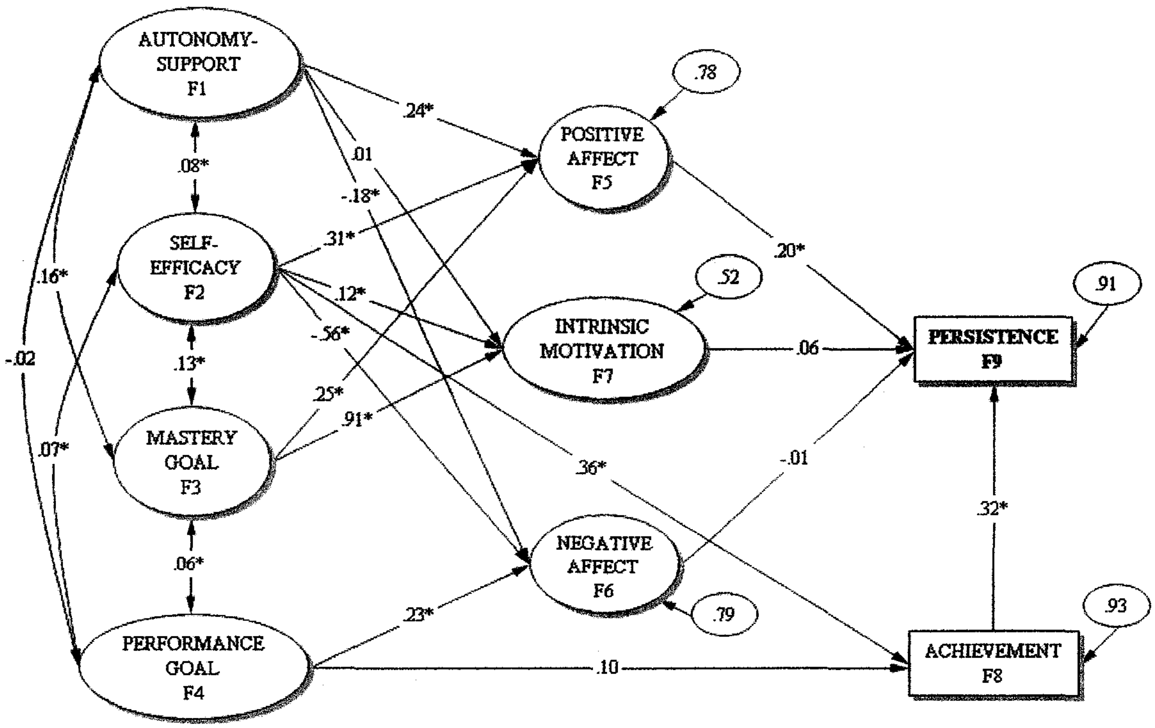


*Figure 11*. Model for men.

*Persisters and resisters.* Given the large differences found between persisters and resisters (see Table 5), the model was tested separately for the sample of 978 persisters and 331 resisters. The factor "persistence" was therefore removed from the model, and the model was tested with intrinsic motivation, positive affect, negative affect, and achievement as dependent variables. The model to be tested is presented below in Figure 12.

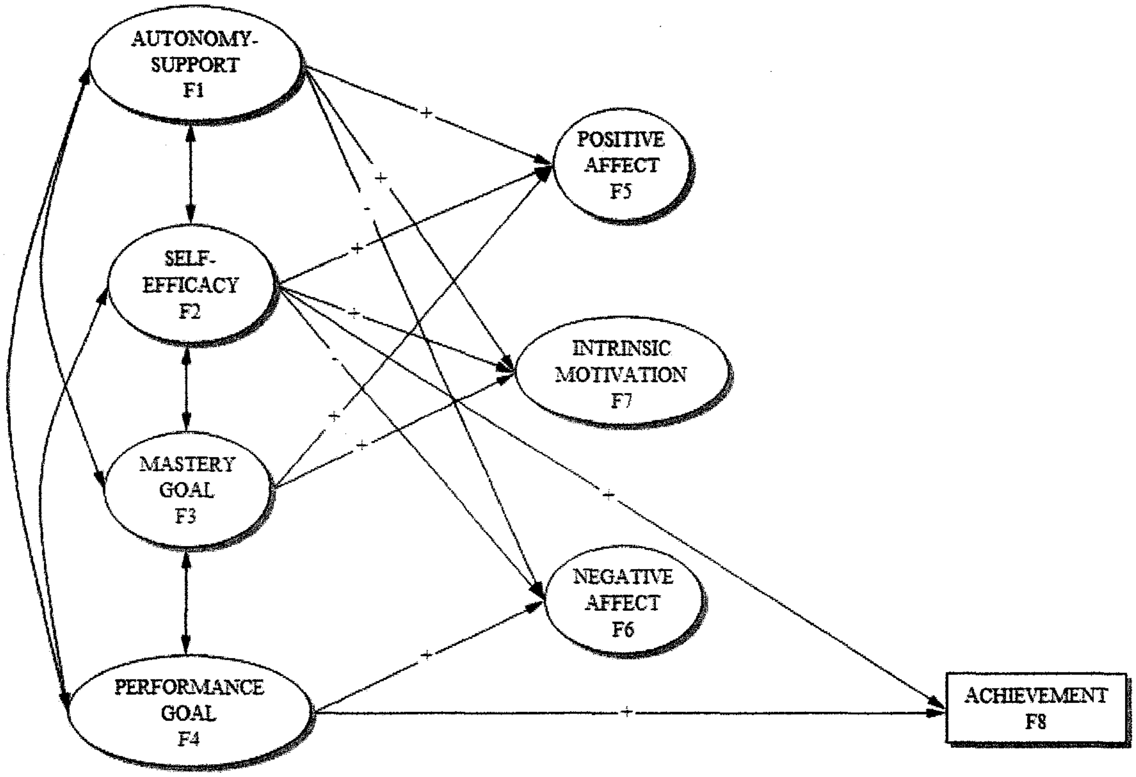


*Figure 12*. Hypothesized structural model for persisters vs. resisters.

For persisters, the model fit was satisfactory and yielded the following results: $\chi^2$ (90) = 322.57, $p < .001$, $\chi^2$/df = 3.58, CFI = .942, NNFI = .921, and RMSEA = .051. Results of the Wald and LM tests did not recommend any changes to the model. The model for persisters is presented in Figure 13.

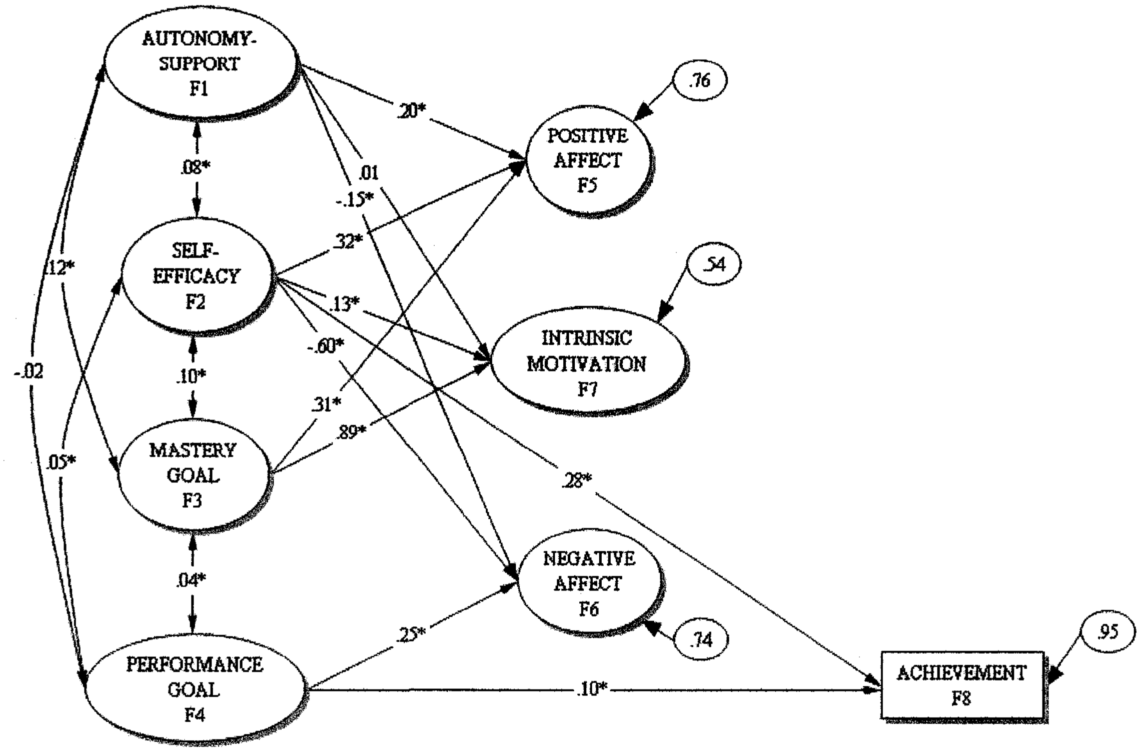


*Figure 13*. Model for persisters.

For resisters, the model fit was satisfactory and yielded the following results: $\chi^2$ (90) = 209.14, $p < .001$, $\chi^2$/df = 2.32, CFI = .924, NNFI = .900, and RMSEA = .063. The Wald test indicated that four parameters were non significant (F8,F4, F5,F1, F6,F1, and F4,F3). Re-running the model without the non significant paths yielded the following results: $\chi^2$ (94) = 211.69, $p < .0001$, $\chi^2$/df = 2.25, CFI = .925, NNFI = .903, and RMSEA = .062. The model for resisters is presented in Figure 14.

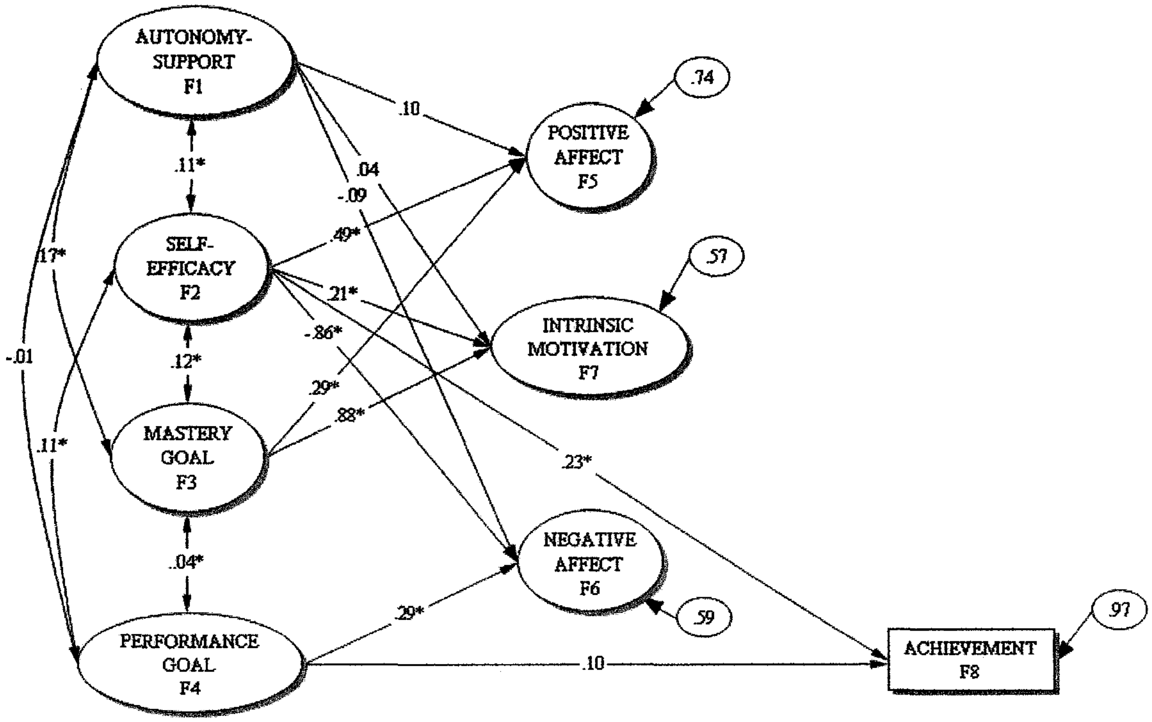


*Figure 14*. Model for resisters.

## *Comparison Between Groups*

*Sex.* Several differences were found between the best fitting models for men and women. First, whereas for women, perceptions of autonomy-support were unrelated to their affect ($\beta = .09$ for positive affect and $\beta = -.10$ for negative affect, $p > .05$), for men feeling autonomous was related to higher positive affect ($\beta = .24$, $p < .05$) and lower negative affect ($\beta = -.18$, $p < .05$). Second, for women, adopting performance goals was positively related to achievement ($\beta = .16$, $p < .05$) whereas for men, this path was not significant ($\beta = .10$, $p > .05$). In order to examine less apparent differences between the models for men and women, a test for invariance across sex was conducted to examine whether the path coefficients in the male and female models are significantly different from each other (Byrne, 2001). A series of equality constraints was specified to test whether the strength of the relationships between variables was equivalent for men and women. As indicated by a CFI of .934, NNFI of .917, $\chi^2$ (219) = 588.09, $p < .0001$, and $\chi^2$/df = 2.68, the results for this test of the structural model indicated a fairly good fit to the data. The validity of the imposed equality constraints was examined using both univariate and multivariate tests. The probability value for one of the constraints was significant (F6,F2) indicating that the relationship between self-efficacy and negative affect is significantly stronger for women ($\beta$ = -.76) than for men ($\beta$ = -.56).

*Persistence.* Several differences were found between the best fitting models for persisters and resisters. First, whereas for resisters, perceptions of autonomy-support were unrelated to their affect ($\beta$ = .10 for positive affect and $\beta$ = -.09 for negative affect, $p > .05$), for persisters feeling autonomous was related to higher positive affect ($\beta$ = .20, $p < .05$) and lower negative affect ($\beta$ = -.15, $p < .05$). Second, for resisters, adopting performance goals was unrelated to achievement ($\beta$ = .10, $p > .05$) whereas for persisters, the path was significant ($\beta$ = .10, $p < .05$). In order to examine less apparent differences between the models for persisters and resisters, a test for invariance was conducted to examine whether the paths that exist in both the persisters and resisters models are significantly different in terms of the strength of the relationships between variables (Byrne, 2001). A series of equality constraints were specified to test whether the strength of the relationships between variables was equivalent for persisters and resisters. As indicated by a CFI of .939, NNFI of .923, $\chi^2$ (191) = 565.44, $p < .0001$, and $\chi^2$/df = 2.96, the results for this test of the structural model indicated a fairly good fit to the data. The validity of the imposed equality constraints was examined using both univariate and multivariate tests. The probability values for three of the constraints were significant

(F5,F2, F6,F2, and F7,F2) indicating that the relationship between self-efficacy and positive affect is significantly stronger for resisters ($\beta = .49$) than for persisters ($\beta = .32$), the relationship between self-efficacy and negative affect is significantly stronger for resisters ($\beta = -.86$) than for persisters ($\beta = -.60$), and the relationship between self-efficacy and intrinsic motivation is significantly stronger for resisters ($\beta = .21$) than for persisters ($\beta = .13$).

# Chapter 5

## *Discussion*

The purpose of this study was to examine newly admitted CEGEP students' perceptions of their experiences with mathematics and science in high school and to propose and test a structural equation model of persistence based in part on Deci and Ryan's self-determination theory (1985) and also including elements of achievement goal theory and research on academic emotions. This study examined how male and female persisters and resisters viewed their high school mathematics and science classes, and sought an understanding of how various factors related to the student and to the classroom environment interact to differentially predict persistence in science for men and women. Specifically, the study examined whether students' perceptions of autonomy-support, self-efficacy, and achievement goals (i.e., mastery and performance goals) predicted their intrinsic motivation to attend CEGEP and their affect in mathematics and science classes, and whether their motivation and affect predicted their achievement and persistence in science. One of the strengths of the design of this study is that participants were already enrolled in CEGEP when they reported on their experiences in high school. Many prior studies that examined student persistence in science at the high school level focused on student intentions to pursue postsecondary studies in science, not on their actual pursuit of such studies. Many have found a poor relation between intentions and actual behavior (e.g., Manski, 1990; Okun, Ruehlman, & Karoly, 1991). The present study therefore improves on prior research in that the outcome variable (persistence) was directly observed rather than based on participant reports of their intentions. In addition, student achievement was not assessed by student report but rather by official records obtained from the Quebec Ministry of Education, thereby avoiding errors in student recall of their achievement in high school. A summary of the findings is followed by their implications for both self-determination theory and the issue of persistence in science.

*Summary of Findings*

*Sex differences.* In their high school mathematics and science courses, women experienced significantly more negative affect and had significantly lower science self-efficacy than men, a finding that has been observed in previous studies (e.g., Eccles, 1994; Seymour, 1995; Zeldin, Britner, & Pajares, 2007). Effect sizes for these differences were moderate (.32 and .55, respectively). However, negative affect did not predict persistence in the model as hypothesized, and therefore, despite the significant sex difference in negative affect, it is unlikely that women's greater negative affect led them to be less likely to persist in science than men. Self-efficacy, on the other hand, directly predicted achievement in all models, and achievement was positively related to persistence. In fact, achievement explained more of the variance in persistence than any of the other variables in the model. This result lends support to social cognitive theory (Bandura, 1986) and the notion that feelings of self-efficacy are central in explaining individuals' achievement, motivation and persistence in the face of difficulty (e.g., Bandura, 1997; Chemers et al., 2001). The significant sex difference in self-efficacy beliefs, coupled with the finding that self-efficacy is an indirect predictor of persistence (through its impact on achievement), provides a possible explanation for the lower persistence of women as compared to men (72.7% of women vs. 77.1% of men were enrolled in science in CEGEP). This finding is consistent with reports from the

Association of American University Women that stated that confidence is the central sex-related predictor of persistence in the area of science and mathematics (cf. Davis & Steiger, 1996). With respect to other significant sex differences, women were more intrinsically motivated than men, and were more mastery-oriented, but also more avoidance-oriented than men. The magnitude of the effect sizes for these differences was small (below .20). Men and women did not differ in their perceptions of the learning environment (in terms of autonomy-support and perceptions of relatedness), their positive affect, their adoption of performance goals, or in their high school mathematics and science grades (women had slightly higher grades but this difference was not significant). These results are somewhat surprising given previous research that has reported that women have fewer opportunities for autonomy than men in the science classroom because men tend to dominate classroom discussion and are more active in the classroom than women (Beaman, Wheldall, & Kemp, 2006; Guzzetti & Williams, 1996). Furthermore, women's affective experiences in science are reportedly often less positive than men's experiences, because of both the competitive nature of the science classroom and women's low confidence in their ability to succeed in science (Parker & Rennie, 2002). Such past findings might lead one to expect that women would feel less autonomous and less positive affect than men, but this was not the case. In addition, previous research has shown that men tend to be more performance-oriented than women, a finding that was not replicated in the present study. Though contradictory to previous research, these findings are encouraging because they suggest that in our sample of Quebec CEGEP students, men and women perceived their high school science classes as equally autonomy-supportive, a condition that is necessary if the basic need for autonomy is to be satisfied. However, although their perceptions may be the same, their impact is different as seen from the models. For males, perceptions of autonomy-support positively increased their positive affect, while for females the impact of an autonomy-supportive environment was negligible. For males, there was a strong link between positive affect and persistence while the link was weaker for women. It is also encouraging that women are reportedly as performance-oriented as men, especially given the fact that a performance orientation is a predictor of achievement for women. With respect to affect, it is encouraging that women report a similar frequency of positive affect as men, but there still remains a significant discrepancy in terms of negative affect.

*Differences between persisters and resisters.* In terms of differences between persisters and resisters, significant differences emerged across most variables, indicating that students' experiences in high school had a significant impact on whether they would enroll in a science program at the CEGEP level. Persisters felt significantly more autonomous in their high school mathematics and science courses, more related, more self-efficacious, more intrinsically motivated, experienced more positive affect and less negative affect, and were more mastery and performance oriented than resisters. Effect sizes were moderate for self-efficacy (.37), positive affect (.47), and negative affect (.36), and were relatively small for autonomy-support (.34), relatedness (.20), intrinsic motivation (.28), mastery goals (.33) and performance goals (.19). Persisters also had significantly higher grades in high school mathematics and science courses than resisters, even though resisters had sufficient grades to be admitted to a science program. The effect size for achievement was large (.89). These results are all in line with previous research on persistence that suggests that perceptions of classroom experiences (which impact on autonomy and relatedness), self-efficacy, achievement goals, and affect, are stronger and more positive in students who persist as compared to students who change programs. In addition, the models tested support existing research that has shown students' achievement to be the best predictor of persistence (e.g., Strenta et al., 1994).

Interestingly, female persisters looked more like male persisters than female resisters (i.e., the differences between female persisters and male persisters were small in comparison to differences between female persisters and female resisters). Whereas the only statistically significant differences between female persisters and male persisters were in terms of self-efficacy and negative affect, female persisters and female resisters differed significantly on all but two of the variables assessed. Similarly, female resisters looked more like male resisters than female persisters (i.e., the differences between female resisters and male resisters were small in comparison to differences between female resisters and female persisters). Whereas the only statistically significant differences between female resisters and male resisters were in terms of self-efficacy, negative affect, intrinsic motivation and mastery goals, as mentioned above female persisters and female resisters differed significantly on all but two of the variables assessed. These results suggest that although men were more likely to persist than women, it was student's experiences during high school rather than sex *per se* that determined whether they would persist or not. In addition, these results suggest that promoting persistence in science should not focus solely on improving persistence for women, but rather that efforts need to focus on improving the experiences of both sexes to optimally promote persistence for the greatest number of students. Now that the results of the MANOVA analyses have been discussed, we proceed to examining the results of the structural equation modeling.

*The Measurement Model*

Results of the first-order confirmatory factor analysis revealed that the questionnaire had good construct validity (convergent and discriminant). All indicators (i.e., questionnaire items) specified to measure a common underlying factor had relatively high standardized loadings on that factor (above .60), and the correlations between the factors were not excessively high (e.g., > .60). All questionnaire items loaded on the factors they were intended to measure (and only on those factors) and operated similarly across sex as well as persistence showing their stability and pervasiveness. Specifically, the items comprising the questionnaire were found to operate equivalently across sexes as well as persisters vs. resisters, and the factorial structure of the questionnaire was found to be equivalent across these groups.

Minor but significant differences were found when the tests for invariance across factor covariances were conducted to measure whether the questionnaire operated similarly for men and women, as well as persisters and resisters. For the comparison between men and women, the covariance between self-efficacy and autonomy-support was found to vary, while for the comparison between persisters and resisters, the covariances between positive affect and intrinsic motivation, and between self-efficacy and performance-goal orientation were found to vary. These results are difficult to interpret but point to possible particularities of the measurement instrument used, as well as subtle ways in which different groups respond to the same measurement instrument.

Future research using this measurement instrument is therefore needed to see whether these results will be replicated with another comparable sample.

*The Structural Model*

By and large, the hypothesized structural model fit the data well and most hypotheses were confirmed. Overall, the structural model accounted for 44% of the variance observed in positive affect ($r^2 = .44$), 51% of the variance in negative affect ($r^2 = .51$), 71% of the variance in intrinsic motivation ($r^2 = .71$), 12% of the variance observed in achievement ($r^2 = .12$) and 15% of the variance observed in persistence ($r^2 = .15$).

Some of the hypothesized links supported by self-determination theory were confirmed, while others were not. Students who felt autonomous felt more positive affect (hypothesis 1b) and less negative affect (hypothesis 1c). Positive affect, in turn, was associated with greater persistence (hypothesis 4a). Specifically, students who felt that they were encouraged to think for themselves, understand new ideas, and share their prior knowledge with the teacher were more likely to report a high frequency of positive feelings in the classroom and a low frequency of negative feelings than those students who did not feel this way. In turn, students who felt a high frequency of positive feelings were more likely to persist in their science studies than those who did not. These results are supported by prior research on self-determination theory (e.g., Assor & Kaplan, 2001) that has demonstrated the importance of autonomy-supportive academic settings for promoting student well-being and persistence.

Similarly, students who felt competent also felt more positive affect (hypothesis 2b) and less negative affect (hypothesis 2c), and received higher grades (hypothesis 2d) than students who did not feel competent. Positive affect and achievement both contributed to greater persistence (hypotheses 4a and 6, respectively). Students who felt confident that they had good knowledge of the subject matter, that they could successfully complete course requirements, and that they would receive good grades in their mathematics and science classes reported a high frequency of positive feelings and a low frequency of negative feelings. They also received higher grades than those who did not feel as competent. These results are again in line with prior research on self-determination theory and self-efficacy theory that has demonstrated a positive relation between feelings of competence, positive affect, and achievement.

Also in line with self-determination theory, students who felt competent also tended to be intrinsically motivated (hypothesis 2a). When students felt confident in their ability to succeed in their science courses, they were more likely to report that they were going to CEGEP because they wanted to broaden their knowledge about subjects that appealed to them. Results of the present study differ from previous research on self-determination theory regarding the role of intrinsic motivation and its relation to autonomy-support. In the present study, student perceptions of autonomy-support were unrelated to their intrinsic motivation (hypothesis 1a), and their intrinsic motivation was unrelated to their persistence (hypothesis 5). Possible reasons for these results are discussed below (p. 113).

With regard to the links supported by goal-orientation theory, all hypotheses were confirmed. A mastery orientation was positively related to intrinsic motivation (hypothesis 3a) and to positive affect (hypothesis 3b), while a performance orientation was positively related to negative affect (hypothesis 3c) and to achievement (hypothesis

3d). Specifically, students who were mastery-oriented put effort into their schoolwork because they inherently enjoy learning new things. These students would therefore be more likely to report feeling positive affect in the science classroom because of the opportunity for learning new information in such a context, and to report that they were attending CEGEP for the same reason. Students who were more performance-oriented, on the other hand, put effort in their schoolwork in order to outperform other students. These students received higher grades than those students who were not as performance-oriented, but they also reported more negative affect in the classroom, likely because they were busy worrying about the need to surpass other students rather than simply enjoying the opportunity to learn new concepts.

With regard to the mediating role of classroom affect, as hypothesized, positive affect was positively related to persistence (hypothesis 4a), but, contrary to expectations, negative affect was not related to persistence (hypothesis 4b). The best-fitting model therefore differed from the originally hypothesized model with regard to three relationships: (a) autonomy-support and intrinsic motivation (hypothesis 1a), (b) intrinsic motivation and persistence (hypothesis 5), and (c) negative affect and persistence (hypothesis 4b). Possible reasons for these differences are discussed next.

*Autonomy and intrinsic motivation.* In all of the models tested, autonomy-support was not related to intrinsic motivation as hypothesized, despite a moderate correlation between the two variables ($r = .29$ and Cohen's $d = .46$). Students who are actively engaged in their studies invest a great deal of effort in learning and show high levels of persistence in their studies (Assor et al., 2005). According to most researchers in academic motivation (e.g., Deci & Ryan, 2002; Vallerand, Fortier, & Guay, 1997), when students are given some control over the content, pace, or type of instruction, their intrinsic motivation to learn and persist is enhanced. When instructors allow students to share their thoughts and ideas about course content, they promote the sense that students are capable and valuable members of the learning environment. In contrast, teachers who maintain control over all aspects of the learning environment convey the message that students have little to contribute to the instruction, and indirectly, that their thoughts and ideas are not valued or considered relevant or important. In the present study, autonomy-support was not related to intrinsic motivation in the models tested. There are two possible reasons why the expected relationship did not emerge. The first has to do with the role of mastery goals and the second has to do with the way intrinsic motivation was measured. With respect to the first possible reason, the association between a mastery orientation and intrinsic motivation was quite strong ($\beta = .89$, $p < .05$) and may have overshadowed an effect of autonomy-support. In other words, when students adopt mastery goals in addition to perceiving an autonomous classroom, this may have a greater influence on motivation than autonomy-support alone and it may negate the effect of autonomy-support. Autonomy-support may only add very little in explaining the variance in motivation while mastery goals explain a lot more. In addition, given the significant covariance between autonomy-support and mastery goals (.16, $p < .05$), it is possible that autonomy-support had an indirect impact on motivation since students who felt more autonomous were more likely to adopt mastery goals.

The second possible reason has to do with the way motivation was measured in the present study. The items chosen were designed to assess the academic motivation of postsecondary students within the framework of self-determination theory. It was hypothesized that although it should be important for all students to be intrinsically motivated to attend CEGEP, it would be especially important for science students to be intrinsically motivated because science is generally considered to be the most difficult and demanding of all academic programs. Because of the nature of science programs, students must truly enjoy learning for the sake of learning because if they do not, they will be more likely to be quickly discouraged by the inherently difficult nature of such programs. Despite the fact that persisters were significantly more intrinsically motivated than resisters, the items used to measure intrinsic motivation were not specific to science; rather they reflected a more general tendency to prefer learning experiences that are intrinsically pleasurable. It is perhaps for this reason that autonomy-support did not predict students' intrinsic motivation as expected. Although the items may have predicted those students who simply chose to persist in their education or not (i.e., enroll in CEGEP or cease their studies), they were not specific enough to differentiate between those students who persisted in science versus those who persisted in their studies, but not in the area of science. Nevertheless, autonomy-support and motivation were moderately positively correlated, meaning that students who felt autonomous also tended to feel intrinsically motivated.

*Intrinsic motivation and persistence.* Contrary to expectations as well, in the present study the link between intrinsic motivation and persistence in science was not significant. Again, the items used to measure intrinsic motivation were not specific to the area of science and therefore may not have been able to differentiate between persisters and resisters since all subjects chose to enroll in CEGEP. Students who reported going to CEGEP for intrinsic reasons were therefore no more likely to enroll in science than they were to enroll in another subject area. Although intrinsic motivation did not predict persistence, persisters were significantly more intrinsically motivated than resisters. Thus, it is possible that the high intrinsic motivation of students who enrolled in science in CEGEP might predict those students who persisted in their science studies after one semester and those who chose to abandon their science studies after one semester. This hypothesis is being investigated by a group of researchers at one of the CEGEPs.

*Affect and persistence.* Experiencing positive feelings in the science classroom positively influenced students' decisions to enroll in science in CEGEP. Interestingly, experiencing negative feelings did not negatively influence persistence. One plausible explanation for this result is that, overall, students felt much more positive than negative affect in the classroom, and this was true for both men and women (Cohen's $d = 1.06$). If students more often experience positive rather than negative affect in the classroom, it may be this emotion that more strongly influences their persistence. Furthermore, research by Rosenfield et al. (2005) has indicated that, when offered a choice, students prefer to recall and discuss a positive, rather than a negative, experience in science. When Rosenfield et al. administered a second questionnaire to the students in the current study after their first semester of CEGEP, and asked them to focus on a particular mathematics or science course when responding to the questionnaire items, most students chose to think about a course that they liked rather than disliked. Specifically, students were given a questionnaire similar to the one used for the current study, including the items assessing students' perceptions of the learning environment (i.e., perceptions of autonomy-support and relatedness), and were asked to respond to the items by focusing on one specific science or mathematics course that they took during their first semester in CEGEP. They were also asked to describe how the course they chose affected them by stating whether the course made them feel (a) very satisfied, (b) satisfied, (c) unsatisfied, or (d) very unsatisfied. A vast majority of students (76%) chose to focus on a course with which they were either satisfied or very satisfied. So it appears that students prefer to think about positive experiences and not negative ones, and so positive affect may be a more influential emotion when it comes to predicting persistence. Future research on academic emotions and their relation to persistence is needed to further support this interpretation.

A striking result is the significant sex difference in negative affect, with women experiencing significantly more negative affect than men (Cohen's $d = .32$). Given that women's perceptions of autonomy-support were not linked to their affect, that women's self-efficacy was strongly linked to negative affect, and that women experienced more negative affect than men, this likely explains why women felt more negative affect in the classroom than men. Some research on affect and interest has suggested that, given that women tend to experience more negative affect, this may in part explain their lower persistence relative to men (Seymour, 1995; Strenta et al., 1994). However, in the present study, it was both male and female students' positive rather than negative affect that influenced their persistence.

*Sex Differences in the Model*

When the full structural model was re-run to test for differences in the model according to sex, some differences emerged. The best fitting models for men and women were quite similar overall but differed with regard to two relationships between variables: (a) the relationship between autonomy-support and affect, and (b) the relationship between a performance goal orientation and achievement. Possible reasons for these differences are explored below.

*Autonomy-support and affect.* Feeling autonomous was linked to higher positive affect and lower negative affect for men but this pattern did not occur for women. Instead, autonomy-support was not significantly related to affect for women. Although the need for autonomy is generally viewed as a universal need that exists for both sexes, in the current study, feeling autonomous was not associated with increases in positive feelings or decreases in negative feelings for women.

An interesting hypothesis that may explain this finding can be found in the nature of the science classroom and women's learning styles. Women may actually prefer more teacher-centered science classrooms as opposed to those where they are responsible for various aspects of the content of their classes. Given women's low levels of self-confidence in science, they may not feel adequately prepared to take on more responsibility in the classroom and may feel more comfortable taking a more passive and dependent role (Jones & Wheatley, 1990). Women may therefore prefer a more structured learning environment than men and therefore may not need to feel as autonomous as men in that particular environment. This is not to say that the need for autonomy does not exist for women in science. Rather, it suggests that women's early socialization experiences may lead them to feel less confident and more dependent in the science classroom, thereby making autonomy-support a less desirable state than it is for men whose early experiences have given them the confidence to seek out and enjoy autonomous learning experiences.

Research suggests that, relative to boys, girls are more compliant to their teachers and parents and women tend to be less assertive than men (Assor et al., 2005). Women may be more passive in the classroom, especially in science, because they tend to be less confident than men in their ability to succeed in science. They may also be more passive because of the competitive nature of many science classrooms, where men tend to dominate classroom discussion and create a climate of individual competition rather than cooperation (Beaman et al., 2006; Guzzetti & Williams, 1996). For this reason, controlling classrooms may be less detrimental to women who are more used to accepting direction from adults and who may prefer to adopt a more passive role in the science classroom. However, it is unlikely that self-determination theory would support the notion that controlling behaviors are less harmful for women because the need for autonomy is seen as a universal human need. In a study by Assor et al. (2005), 319 4th and 5th graders completed questionnaires assessing their perceptions of the teachers' controlling behaviors, negative emotions, extrinsic and amotivation, and engagement while studying in the teachers' classes. Controlling teacher behaviors had negative effects on emotions, motivation, and engagement, for both boys and girls. In other words, controlling teacher behaviors are as harmful for girls as they are for boys. Future research is needed to shed light on the result obtained in the current study. There is no doubt that providing students with a sense of autonomy is an important educational objective. However, efforts must begin early if women are to be socialized to feel confident enough about their ability to succeed in science to be able to enjoy and benefit from autonomy-supportive learning experiences in high school.

*Performance goals and achievement.* For men, performance goals were not linked to achievement ($\beta = .10, p > .05$), while for women the link was small but significant ($\beta = .16, p < .05$). The question arises as to whether this indicates a true difference between men and women in terms of the relationship between performance goals and achievement. Although the link was significant for women, the value of the path coefficient was small and therefore not a clear association. It is however plausible that adopting performance goals is somewhat more necessary for women in achieving good grades in science than it is for men. In other words, for women to succeed in science, they may need to be somewhat more competitive than men. Further research is needed to shed light on this result. Given that only high achieving students were included in the sample, the range of achievement scores is fairly limited (70% to 98%). Most studies that have found a positive relationship between performance goals and achievement have examined whole classrooms with students who obtain a wide range of grades. In such studies students who do not adopt performance goals tend to be those who receive poor grades thereby confirming the relationship between goals and performance. However, given that in the present study all students obtained relatively satisfactory or high grades (i.e., above 70), it is possible that performance goals could not predict achievement for an already high-achieving group. In other words, performance goals may have predicted achievement if both high- and low-achieving students were included in the sample.

Although the majority of prior research has found a positive relation between performance goals and achievement (e.g., Harackiewicz et al., 2000; Pintrich, 2000), some existing research supports the finding of the present study (Brophy, 2005; Kaplan & Maehr, 1999; Roeser, Midgley, & Urdan, 1996). Brophy (2005) pointed out that the correlational relationships developed from questionnaire data cannot be assumed to be causal. Most studies have demonstrated that performance goals show weak but positive (averaging about .20) correlations with actual performance. Harackiewicz, Barron, Pintrich et al. (2002) similarly reported positive but low regression coefficients in their review of 14 studies done at the college level. Correlational data are often misinterpreted as implying causal relationships but such interpretations are faulty (Byrne, 2001). Therefore, the results obtained in the present study seem to support existing research demonstrating a positive but weak relationship between performance goals and achievement. Generally, researchers agree that mastery goals are more strongly linked to outcomes such as persistence, interest, and motivation than performance goals (Harackiewicz, Barron, Tauer, et al., 2002). More research is needed to clarify the link between performance goals and achievement for high-achieving students in academic settings.

*Persisters versus Resisters*

Interestingly, the differences between the best-fitting models for persisters and resisters mirrored the differences between the best-fitting models for men and women. In other words, the model for persisters resembled the model for men (minus the persistence variable), while the model for resisters resembled the model for women (minus the persistence variable). Specifically, autonomy-support was significantly related to affect for persisters, as was the case for males. In contrast, autonomy-support was not significantly related to affect for resisters, as was the case for females. Given that resisters felt significantly less confident than persisters, like women, resisters may not derive their affect from their perceptions of autonomy-support but rather from their self-efficacy beliefs. This statement is further supported by the fact that the tests for invariance between the models for persisters and resisters revealed that the strength of the relationship (i.e., path coefficient) between self-efficacy and affect (both positive and negative) was significantly stronger for resisters. These results support the notion that, as for women, perceptions of confidence are essential in explaining persistence.

*Relatedness*

Past research indicates that when students feel related to one another and involved in a community of learners, they are more likely to experience self-determined forms of motivation, particularly intrinsic motivation. Perceptions of relatedness were not related to intrinsic motivation in the present study. There are at least three plausible reasons why the relationship did not emerge as expected: (a) how collaborative learning or group work is carried out, (b) relatedness and autonomy-support are highly correlated (.50) and the need for relatedness may be more distal than the need for autonomy-support, and (c) how relatedness was measured.

Some evidence (e.g., Guzzetti & Williams, 1996; Seymour, 1995) suggests that, in many science classrooms, collaborative activities actually promote competition rather than a sense of relatedness. In laboratory group work, for example, students are often put in small groups and required to solve a particular problem by working together. These small groups often compete with each other to see which group solves the problem first. Such activities are not structured in a way that promotes a sense of relatedness. Nevertheless, according to Deci and Ryan (2002), evidence which closely links competence and autonomy-support to intrinsic motivation is considerably more plentiful than that which links relatedness to intrinsic motivation. Indeed, there are many solitary activities for which people maintain high intrinsic motivation without feeling related to anyone. Accordingly, Deci and Ryan (2000) have suggested that relatedness typically plays a more distal role in the promotion of intrinsic motivation than competence or autonomy-support. Even though relatedness is essential for well-being, and is an important human need throughout the lifespan, this need may be distal for certain tasks and situations.

In the present study, the items on the relatedness scale asked students whether they had opportunities to engage in cooperative and group learning and whether or not this influenced their learning. The items did not specifically ask students whether or not they felt related while engaging in these activities. It is possible that, for some students, simply engaging in group work did not necessarily lead them to feel related to other students. According to self-determination theory, individuals must not only be in a situation that offers the opportunity to be related, but must also feel subjectively related to others in order for this need to be met. The adaptation of test items designed for the larger research project did not make it possible to be fully true to the theoretical framework, which probably explains the results obtained.

*Promoting Persistence in Science*

*The role of self-efficacy.* Self-determination theory posits that the more competent students perceive themselves to be in a given domain, the more intrinsically motivated they will be when they engage in the activity. This was indeed the case in the present study, for both men and women. Students who had high self-efficacy beliefs in mathematics and science tended to be more intrinsically motivated. In addition, self-efficacy directly predicted students' achievement, indicating that students who strongly believed they could succeed in mathematics and science actually did. Self-efficacy therefore plays a central role in influencing student performance in science and indirectly influences their persistence. Furthermore, as mentioned above, differences in self-efficacy provide one plausible explanation for the lower persistence of women (DeBoer, 1987; Eccles, 1994; Seymour, 1995). Our current research is examining how students' science self-efficacy changes over the two years of CEGEP as a direct result of science instruction. Preliminary analyses reveal that self-efficacy drops after one semester of CEGEP for both sexes and that this drop is related to students' decisions to switch out of science after one semester (Rosenfield et al., 2005).

Although self-efficacy beliefs may change as a result of educational experiences, research has shown that they develop well before school age, so attempts to influence self-efficacy must begin early. The family and home environments are therefore pivotal. Early experiences that provide children with opportunities to interact successfully with the environment positively affect their self-efficacy beliefs (Schunk & Pajares, 2001). By encouraging exploration of the environment, stimulating curiosity, and providing children with opportunities to be challenged while experiencing success, parents and teachers can promote students' beliefs that they can overcome obstacles and experience success, even when confronted with unfamiliar situations.

Researchers generally agree that both inside and outside of classrooms, males have more opportunities to experience science than females (Jones & Wheatley, 1990; Miller, Blessing, & Schwartz, 2006). Therefore children, and especially girls, need early opportunities to engage in science-related activities that are challenging but offer opportunities for mastery. Children should have access to books about science, computers, and visits to science museums, for example. Given the consistent finding of lower science self-efficacy of women, parents and teachers should make an effort to expose students to female scientist role models. Because girls tend to have lower self-efficacy in science, mathematics, and technology as compared to boys, despite equal achievement, particular attention should be paid to encourage girls to participate in science-related activities, provide positive feedback and encouragement, and provide them with female role models to whom they can look up and strive to emanate. According to Schunk and Pajares (2001), "One challenge before educators is to alter students' views of academic subjects so that they are perceived as relevant and valuable both to girls and boys" (p. 12). Since science self-efficacy is a direct predictor of students' achievement and motivation, as well as an indirect predictor of persistence, efforts should be made to promote students' sense of science self-efficacy since this may encourage more students to enter and persist in science-related programs and careers.

According to Bandura, self-efficacy is influenced by four factors: past performance, vicarious experiences, emotional arousal, and verbal persuasions. With respect to vicarious experiences, peers can positively influence children's self-efficacy. Observing similar others succeed can raise children's self-efficacy and motivate them to perform the task if they think they will be successful too (referred to as model similarity). Therefore, providing opportunities for children to work together and observe their peers being successful in science-related activities may in turn promote their own self-efficacy. With respect to persuasive communications, schools and teachers play a pivotal role. Self-efficacy beliefs tend to decline as students advance through school. Explanations for this decline include greater competition, norm-referenced grading, less teacher attention to individual progress, and stresses associated with school transitions (Schunk & Pajares, 2001). Teachers need to be aware of this decline and should provide all students with opportunities for success and mastery of difficult content. Positive feedback and praise are essential if students are to feel competent in their academic endeavors.

*The science classroom.* Research has shown that the use of controlling practices increases when instructors are under pressure to cover curricula or are evaluated on the basis of students' achievement (e.g., Deci et al., 1991; Pelletier, Séguin-Lévesque, & Legault, 2002). The onus is therefore not only on teachers but also on administrators and those who develop curricula to develop instructional practices that will allow teachers to provide students with opportunities to exert some control over what goes on in the classroom. The results of this study suggest that teachers need to work toward creating a classroom climate in which both men and women participate actively and benefit from the opportunities for autonomy that are created by the instructor. This is especially true for women who may not have the confidence they need to be able to reap the benefits of an autonomy-supportive classroom.

Promoting a mastery-goal orientation in students is also an important educational objective since mastery-oriented students feel more positive and are more intrinsically motivated than students who do not endorse these goals. Performance goals, on the other hand, were associated with greater negative affect and were only weakly associated with achievement. Thus, while a mastery-goal orientation is associated with greater persistence through its impact on student's positive affect, a performance-goal orientation is clearly less beneficial. Teachers therefore need to offer more opportunities for mastery, making lessons relevant to students by inquiring about and then incorporating aspects of students' knowledge and experience into the science curriculum. Creating lesson plans that focus on current topics of interest to students can promote student interest in science thereby increasing the likelihood that they will adopt goals that reflect an inherent interest in the subject matter.

*Promoting Persistence in Science for Women*

Many things can take place outside the science classroom to encourage more women to take interest in and subsequently pursue future education and careers in science. For example, over the past 15 years, the Operation Minerva Program has been providing junior high school students with opportunities to job-shadow women in science and engineering professions, throughout the province of Alberta. Participants follow a mentor and participate in hands-on activities that bring out special aspects of the job (MacDonald, 2005). *Les Scientifines* is a Montreal-based after-school program that serves young girls from low-income communities. The goal of the *Scientifines* program is to develop girls' scientific literacy and understanding of the scientific method through hands-on projects, while exposing them to potentially interesting future career paths (Rahm, Moore, & Martel-Reny, 2005). Intervention programs such as Operation Minerva and *Les Scientifines* positively impact student's attitudes toward science, their science course enrollment, and their consideration of a future science career.

Research examining early childhood reveals that boys tend to be more competitive and individualistic while girls tend to be more cooperative and relational. In addition, throughout childhood, boys tend to report more exposure to science-related activities than girls. Given the way science tends to be taught in high school (i.e., competitive activities, focus on individual achievement), it is no surprise that women tend to lose interest in science during this period. Psychological differences and exposure to early science-related activities highlight the importance of providing women with opportunities to engage in science in a way that takes into account their cognitive style, and to do so at an early age. Exposing women to science early (i.e., in childhood) may help to promote their self-confidence and assurance so that they can benefit more affectively from autonomy-supportive classrooms.

*Limitations and Directions for Future Research*

One of the limitations of this study involves the manner in which the four versions of the questionnaire were constructed. Because each of the four versions contained only two or three of the subscales (except perceptions of autonomy-support and relatedness which were on all four versions), there was a great deal of missing data to be imputed. Although data imputation is the method of choice when dealing with missing data, it remains that the final data set contained less variability and was probably more normally distributed than it would have been were there no missing data. Our current research is correcting this problem by creating questionnaires that include all scales on all versions.

Students' demographic characteristics such as their ethnic background or socio-economic status were not taken into account in the present study. Past research has demonstrated ethnic and cultural differences in science achievement (National Center for Education Statistics, 2000). A team of researchers at one of the CEGEPs is currently examining the impact of cultural and linguistic differences on achievement and persistence in science. In the sample of participants in the current study, 62% of students reported that their mother tongue or language spoken at home was not English. Understanding if and how these linguistic characteristics impact on students' success and persistence in science is important, especially given the amount of cultural and linguistic diversity that exists in Montreal schools.

Although this study used structural equation analyses to test the proposed model, it did not use an experimental or longitudinal design and it is therefore inappropriate to make clear statements concerning directionality or causality (Kline, 1998). This is because the technique of SEM analyses covariances and correlations, and although a substantial correlation could indicate a causal relation, variables can also be associated in ways that have nothing to do with causality. Our current research is using the model developed in the present study to examine the success and persistence of the same participants across their CEGEP studies and on to university. Participants have responded to a similar questionnaire as the one used in the present study after one semester in CEGEP, after three semesters in CEGEP, and into university. The model developed in the present study will be tested to see how well it fits the data obtained at those different time points. We thus hope to be able to reproduce the present findings over time and thereby better understand how students' experiences in CEGEP influence their decisions to pursue science studies in university. Nevertheless, one of the strengths of the present study is that student persistence occurred after their high school experiences, thereby satisfying one of the main conditions for the inference of causality (i.e., time precedence; Kline, 1998). In other words, the variables included in the model were experienced prior to students' enrolment in CEGEP, which lends support for the possibility that those variables in fact predicted persistence.

Finally, this study focused on a small set of factors in line with self-determination theory and achievement goal theory. However, success and persistence in science is a complex phenomenon, likely influenced by numerous other variables. Overall, the structural model accounted for 12% of the variance observed in achievement and 15% of the variance observed in persistence. Thus it would be interesting for future studies to incorporate other important variables into the model to better predict academic success and persistence. Variables such as parenting style (e.g., Baumrind, 1991), parental involvement (e.g., Ratelle, Larose, Guay, & Sénécal, 2005), support (e.g., Niemiec et al., 2006), or integration in the school milieu (e.g., Grayson, 1994) have been shown to influence academic success and persistence.

*Conclusions and Implications*

To address the crisis of decreasing enrollment in postsecondary science and engineering programs and to meet the demands of today's technologically advanced society, it is imperative that we understand the mechanisms and causal pathways that explain this unfortunate and alarming trend. The present study reiterates the need to encourage and support students' autonomy in the classroom by offering choice and encouraging students' active involvement in both the content and enactment of the curriculum. Indeed, the learning environment needs to be a central focus for promoting persistence because the classroom is the main arena within which teachers can influence their students, indeed this may be the only arena within which they interact (Pintrich, 2003; Tinto, 1997). For men, affect mediates the relationship between autonomy and persistence, meaning that men need to feel autonomous in the classroom in order to have a positive affective experience and in turn to persist. Women, on the other hand, seem to derive their affective experience not from teaching practices or classroom context but instead from internal characteristics such as their sense of competence and their personal achievement goals. It is possible that, for those women who have high self-efficacy to begin with, affect may be influenced by their perceptions of autonomy-support but for those with low self-efficacy, the relationship between self-efficacy and affect negates any influence of the classroom environment. This hypothesis merits further investigation.

There is no doubt that efforts need to be made to increase women's sense of competence with mathematics and science, since their tendency to feel less capable than men may result in their lower persistence. In addition, for both sexes, positive affective experiences in the science classroom are an important educational objective because students who report a high frequency of positive affect are more likely to persist than those who do not. Providing positive feedback to students, making classroom activities fun, interesting, and relevant to students are but some ways to encourage positive affect in the science classroom.

Achievement also plays an important role in promoting persistence. If all students in the present study had sufficient grades to enter science programs yet only those with especially high grades actually did, this suggests that very high grades may not only influence persistence directly but may also influence other variables which in turn influence persistence. For instance, high grades promote self-efficacy which may then increase positive feelings in the classroom and therefore promote persistence. Given that the present study was explorative in nature and did not involve a longitudinal design, such relationships could not be explored (i.e., self-efficacy influences achievement which then influences future self-efficacy). However, Rosenfield and colleagues have continued to follow the participants from the present study and will therefore be able to examine these reciprocal relationships over time.

It is imperative that science teachers in both high school and CEGEP be made aware of the alarming rates at which students, and especially women, abandon the study of science. If they do not recognize the current state of affairs, they cannot be expected to be motivated to find ways to alter their own practices in order to try and attract more students to their chosen field. Efforts are currently being made by our research team to provide science teachers with feedback on our research in an attempt to bring the current situation to their attention.

To address the crisis of decreasing enrolment in science in higher education and a lack of qualified scientists and science instructors, it is essential to understand the mechanisms and causal pathways that lead to this unfortunate situation. As demonstrated by this study, perceptions of competence were related to motivation, but the association between autonomy-support and motivation, as well as the association between motivation and persistence is still unclear. Students' achievement goals are associated with motivation and achievement, as previous research has demonstrated. This study extends previous research by including the role of student' classroom affect. Affect is influenced both by students' achievement goals, as well as their sense of competence and autonomy-support. Although the magnitude of the relationship between affect and persistence is relatively small, affect is closely related to students' experiences inside the classroom and therefore deserves close attention when examining outcomes of classroom practices. Individuals concerned with promoting persistence in science need to take into account the goals with which students enter the science classroom, classroom practices which may promote or demote students' autonomy, as well as the subjective experiences of students in the classroom that influence their sense of competence and their overall affect. The task of encouraging more students to pursue science-related careers is therefore complex, but one that deserves effort and attention.

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# Appendices

## **Appendix A: Student Consent Form**

**A Study of the Factors Influencing Success and Perseverance in Careers in Science of CÉGEP Students**

**Directions to the Student**

Quebec lags behind other developed countries in the number of science graduates, as measured by the proportion of degrees earned in the sciences. Many people believe that the wealth of a country may depend upon its ability to educate a growing percentage of people knowledgeable in mathematics and sciences. A team of researchers from Champlain, Dawson, John Abbott and Vanier Colleges, and from Concordia and McGill Universities, is investigating the reasons why students choose or do not choose to pursue further studies in science. Since you have been accepted to CÉGEP in a pre-university program, in applying to a particular program you have already made one such decision concerning what to study and what careers you may then choose.

We would like you to participate in this research by filling in questionnaires inquiring about your views about science/mathematics education and by allowing the college registrar to provide us with information that is in your file at the college. In addition, we may invite a small number of volunteers for short interviews. If you are interested in more information, or the results of this research, please contact the project coordinator, Rebecca Simon, by telephone at XXX-XXXX, or by e-mail at simonrebecca@________

I, the undersigned, consent to participate with the assurance that the data will be kept **confidential** and that they in **no way affect my academic record at CÉGEP**. I understand that I have the right to refuse to participate at any time, and that such refusal will also in no way affect my academic record at CÉGEP. Further, I understand that should I decide to participate at this time, I can subsequently change my mind by sending an e-mail to the project coordinator, **Rebecca Simon**, at **simonrebecca@yahoo.ca**, informing her of my decision. In such a circumstance, all data that I have contributed will be withdrawn and my decision will also in no way affect my academic record at CÉGEP.

DATE: ______________________________

PRINT NAME: ______________________________

STUDENT #: ______________________________

SIGNATURE: ______________________________

# Appendix B: Questionnaire

**Survey of Student Perceptions of High School Experiences**

It is important to understand that there are no right or wrong answers to the questions below. Your answers should reflect what you actually and honestly think. Try not to dwell on any particular question. Instead, respond with what comes to mind when you read the question. Please try to answer all questions that apply to you because doing so automatically places your name in the draw for prizes.

**Please do not make marks on the questionnaire itself.**

**Use a dark pencil and mark one answer per item on the opscan sheet.**

Thank you in advance for your cooperation.

1. Please begin by entering your last name, your first name, and the CÉGEP Identity # that you have been given. Please enter these both in printed letters (in the appropriate spaces) and by colouring the opscan letters with your pencil.
2. Next, in the area labeled Test I.D., please enter 001, both by printing on top and colouring the opscan letters with your pencil.
3. Now proceed to the questions in Part I. As you work through the questionnaire, please be careful to read all instructions.

**Survey of Student Experiences in High School - Amalgam of 4 Versions**

**(Attitudes towards careers in science: found in versions 1, 2, 3, 4.)**

1. Before you entered High School, were you considering a career requiring an education in science?

   **1. Yes 2. No 3. I did not think about it.**

**If you answered 3. (I did not think about it) for Item 1. above, then skip Items 2. - 6. below and go directly to Item 7.**

Items 2. - 6. below each mention a factor which might have influenced your career intention **before** you entered High School. Please rank the impact of each particular factor on the following scale:
**1. Very large impact 2. Large impact 3. Moderate impact 4. Some impact 5. No impact**

2. Parental advice
3. Your own interests
4. A person in your community/family serving as a role model
5. Your teacher(s)/guidance counsellor(s)/school adminiatrator(s)
6. Media (radio, television, movies, newspapers, magazines, etc.)

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**(Attitudes towards learning mathematics: in versions 1, 2, 3, 4.)**

7. My attitude towards math is best characterized by:

**1. I love it 2. I like it 3. I am indifferent to it 4. I dislike it 5. I hate it**

8. Fundamentally this attitude was formed:

**1. Before High School 2. In Sec. I & II 3. In Sec. III 4. In Sec. IV 5. In Sec V**

Various factors may have influenced you to form your attitude towards math. Items 9. - 12. below list such factors. Please rank the impact of each factor on the following scale:
**1. Very large impact 2. Large impact 3. Moderate impact 4. Some impact 5. No impact**

9. family members
10. friends
11. grades in math
12. how math is taught

---

**(Attitudes towards learning science: in versions 1, 2, 3, 4.)**

13. My attitude towards sciences is best characterized by:

**1. I love it 2. I like it 3. I am indifferent to it 4. I dislike it 5. I hate it**

14. Fundamentally this attitude was formed:

**1. Before High School 2. In Sec. I & II 3. In Sec. III 4. In Sec. IV 5. In Sec. V**

Various factors may have influenced you to form your attitude towards science. Items 15. - 18. below list such factors. Please rank the impact of each factor on the following scale:
**1. Very large impact 2.Large impact 3. Moderate impact 4. Some impact 5. No impact**
15. family members
16. friends
17. grades in the sciences
18. how the sciences are taught

---

**(Motivation to select science and mathematics courses: in versions 1, 2, 3, 4.)**
Various factors may have influenced your choice of math or science courses in high school. Items 19. - 24. below list such factors. Please rank the impact of each factor on the following scale:
**1. Very large impact 2. Large impact 3. Moderate impact 4. Some impact 5. No impact**
19. family members
20. friends
21. my attitude towards science
22. my attitude towards math
23. a desire to keep more options open
24. teachers, guidance counsellors or school administrators

---

**(Use of calculators in High School: in versions 1, 2, 3, 4.)**
25. How often did you use a graphing calculator, such as the TI83, in your Sec. IV and/or Sec. V math classes?
**1. Throughout every class 2. Once every class 3. During several classes 4. Never 5. I don't remember**

**If you answered 4. (Never) for Item 25. above, then skip Items 26.- 29. below and go directly to the instructions above Item 30.**

When the graphing calculator was used in learning a topic it could have been used in several ways. The next three items below, 26. - 28., list different ways to use a graphing calculator. Please rank how often you feel the calculator was used in each way on the following scale:
**1. Very often 2. Often 3. Sometimes 4. Never 5. I don't remember**
26. For simple numerical calculation, i.e., to do arithmetic.
27. To generate graphs from a formula or to analyse data, e.g., sorting, averaging.
28. Doing homework for your Sec. IV and/or V math classes.

29. What was the main way that you learned to use a graphing calculator?
**1. Taught by teacher 2. Learned from friends 3. Learned by myself 4. Other**

---

**(Perceptions of science/mathematics instruction in High School: in all versions)**
When completing Items 30. - 57. below, please think specifically about the math and science classes and teachers from high school. When a statement or a question refers to what you did in class, again think specifically about your science and math classes in high school.

**1. Strongly disagree 2. Disagree 3. Neither agree nor disagree 4. Agree 5. Strongly agree**

30. Teachers emphasized the understanding of concepts more than the remembering of formulas.
31. Teachers expected students to take the information presented in class as "fact".
32. Teachers related the information they teach to the "real world".
33. Teachers seemed to lack any motivation to teach well.
34. Teachers attempted to find out what students already know about a topic before presenting new or more advanced information in their classes.
35. Teachers tried to ensure that their students felt confident and competent in their study of math and science.
36. Teachers treated students with respect.
37. Equal opportunities for success in science and math classes were given to students regardless of gender.
38. Teachers explained their ideas in a way that made sense.
39. Teachers lectured most of the time.
40. I spent most of my time in class copying the teacher's notes.
41. Group work in my classes mostly involved repetition of problems where one "plugs-in" numbers into a formula.
42. It was possible to pass science or math exams without really understanding the subject.
43. Teachers related information presented in their classes to other math or science classes.
44. Teachers encouraged me to think for myself.
45. Teachers gave good examples and practical applications of mathematical and scientific concepts.
46. Teachers have been effective in making me learn.
47. Teachers assumed students knew more about math and science than they really do.
48. Teachers encouraged competition for grades amongst students.
49. I feel that teachers treated me unfairly because of my gender.
50. Teachers encouraged students to work together.
51. Teachers had a hard time understanding questions students raised in class.
52. Teachers gave a short lecture and then groups of students worked on problems or discussed topics.
53. Teachers promoted the idea of "discovering things together" with students in their classes.
54. When teachers asked groups of students to discuss a topic, the discussion usually improved my understanding.
55. Lectures stimulated me to think along with the teacher, and to understand new ideas.
56. All we needed to do when solving problems on exams was to match the facts with

equations, and then substitute values to get a number.
57. Teachers encouraged students to participate in classroom discussions.

---

**(Demographic information: socio-economic background and ethnicity: in versions 1, 2, 3.)**

58. Parents' education - in responding to this question think of whichever parent has achieved the highest level of education.

**1. High School certificate or less 2. Bachelor's degree 3. Master's degree 4. PhD 5. I don't know**

59. Family income

**1. less than $15,000 2. between $15,000 and $30,000 3. between $30,000 and $50,000 4. more than $50,000 5. I don't know**

60. What percentage of time do you use languages other than English?

**1. less than 10% 2. between 10% and 30% 3. between 30% and 50% 4. between 50% and 70% 5. more than 70%?**

61. What is the ethnic origin of the parent that you most identify with?

**1. North American 2. European 3. Arabic 4. Latin American 5. Other**

**If you answered 5. (Other) on the previous item, then continue by answering the next item below, Item 62.**
**If you answered 1. (North American) on the previous item, then skip to Item 66.**
**If you answered 2. (European), 3. (Arabic) or 4. (Latin American), then skip Item 62. below and continue by answering Item 63.**

62. What is the ethnic origin of the parent that you most identify with?

**1. Chinese, Vietnamese, Korean or Japanese 2. East Indian 3. African 4. Other**

63. If you were not born in Canada, at what age did you come to Canada?

**1. less than 3 2. between 3 and 5 3. between 5 and 10 4. between 10 and 15 5. older than 15**

64. To what extent do you identify with Canadian culture versus the culture of the parent whose ethnic origin you described above?

**1. I identify only with Canadian culture.**
**2. I identify mostly with Canadian culture.**
**3. I identify strongly with both Canadian culture and the culture of my parent.**
**4. I identify mostly with the culture of my parent.**
**5. I identify only with the culture of my parent.**

65. To what extent do you feel that the cultural values of your parent and Canadian cultural values conflict with each other?

**1. They conflict in many respects. 2. They conflict in some respects. 3. They conflict in a few respects. 4. They do not conflict. 5. I don't know what to think.**

---

**(Epistemological beliefs about knowledge: in versions 1, 4.)**
Please rank Items 66. - 70. below on the following scale:
**1. Strongly disagree 2. Disagree 3. Neither agree nor disagree 4. Agree 5. Strongly agree**

66. Often, a principle or theory just doesn't make sense. In those cases, you have to accept it and move on, because not everything in science or math is supposed to make sense.
67. When learning science or math, people can understand the material better if they relate it to their own ideas.
68. If teachers gave really clear lectures, with plenty of real-life examples and sample problems, then most good students could learn those subjects without doing lots of sample questions and practice problems on their own.
69. When it comes to math and science, most students either learn things quickly, or not at all.
70. Understanding science is important for everyone, not just for scientists.
71. In math and sciences, how do the most important formulas relate to the most important concepts? Please read all choices before picking one.

1. **The major formulas summarize the main concepts; they're not really separate from the concepts. In addition, those formulas are helpful for solving problems.**
2. **The major formulas are kind of "separate" from the main concepts, since concepts are ideas, not equations. Formulas are better characterized as problem-solving tools, without much conceptual meaning.**
3. **Mostly 1., but a little 2.**
4. **About half 1. and half 2.**
5. **Mostly 2., but a little 1.**

72. **Justin**: When I'm learning science concepts for a test, I like to put things in my own words, so that they make sense to me.
**Dave**: But putting things in your own words doesn't help you learn. The textbook was written by people who know science really well. You should learn things the way the textbook presents them.

1. **I agree almost entirely with Justin.**
2. **Although I agree more with Justin, I think Dave makes some good points.**
3. **I agree equally with Justin and Dave.**
4. **Although I agree more with Dave, I think Justin makes some good points.**
5. **I agree almost entirely with Dave.**

73. To be successful at most things in life...

1. **Hard work is much more important than inborn or natural ability.**
2. **Hard work is a little more important than inborn or natural ability.**
3. **Inborn or natural ability and hard work are equally important.**
4. **Inborn or natural ability is a little more important than hard work.**
5. **Inborn or natural ability is much more important than hard work.**

74. To be successful at science…
1. **Hard work is much more important than inborn or natural ability.**
2. **Hard work is a little more important than inborn or natural ability.**
3. **Inborn or natural ability and hard work are equally important.**
4. **Inborn or natural ability is a little more important than hard work.**
5. **Inborn or natural ability is much more important than hard work.**

75. Jessica and Mia are working on a homework assignment together...
**Jessica**: O.K., we just got problem #1. I think we should go on to problem #2.
**Mia**: No, wait. I think we should try to figure out why the thing takes so long to reach the ground.
**Jessica**: Mia, we know it's the right answer from the back of the book, so what are you worried about? If we didn't understand it, we wouldn't have gotten the right answer.
**Mia**: No, I think it's possible to get the right answer without really understanding what it means.
1. **I agree almost entirely with Jessica.**
2. **I agree more with Jessica, but I think Mia makes some good points.**
3. **I agree equally with Mia and Jessica.**
4. **I agree more with Mia, but I think Jessica makes some good points.**
5. **I agree almost entirely with Mia.**

---

**(Independence/interdependence: in versions 1, 3, 4.)**
Please rank Items 76. - 81. below on the following scale:
**1. Strongly disagree 2. Disagree 3. Neither agree nor disagree 4. Agree 5. Strongly agree**
76. I will sacrifice my self-interest for the benefit of the group I am in.
77. I enjoy being unique and different from others in many respects.
78. Having an active imagination is important to me.
79. It is important to me to respect decisions made by the group.
80. My personal identity, independent of others, is very important to me.
81. I will stay in a group if they need me, even when I'm not happy with the group.

---

**(Self-efficacy beliefs: in versions 1, 3, 4.)**
Please rank Items 82. - 87. below on the following scale:
**1. Strongly disagree 2. Disagree 3. Neither agree nor disagree 4. Agree 5. Strongly agree**
82. I am unsure that my grades in math or science courses will be good.
83. I am confident that my solutions for math and science problems are usually correct.
84. I think I have a good knowledge of basic concepts in math and science.
85. I write math and science exams much less confidently than exams in other subjects.
86. I can succeed in math or science classes.
87. I can do even the most difficult problems in the math or science textbook.

---

**(Valuing of success in science and mathematics: in versions 1, 2, 3, 4.)**

88. It is very important to me to have good grades in math and sciences.

**89. It is very important to me to have good knowledge of basic concepts in math and sciences.**

---

**(Affect towards science and mathematics: in versions 1, 3, 4.)**

Items 90. - 98. consist of a number of words that describe different feelings and emotions that you may have experienced in high school math and/or science classes. For each item indicate how often you felt this way using the following scale:

**1. Very rarely or not at all  2. Just a few times  3. Often  4. Quite often  5. Very often**

90. Joyful
91. Unhappy
92. Worried/Anxious
93. Enjoyment
94. Depressed
95. Pleased
96. Happy
97. Angry/Hostile
98. Frustrated

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**(Goal orientation: in versions 2, 3.)**

Please rank Items 99. - 110. below on the following scale:

**1. Strongly disagree  2. Disagree  3. Neither agree nor disagree  4. Agree  5. Strongly agree**

99. I like school work that I'll learn from, even if I make a lot of mistakes.
100. I would feel really good if I were the only one who could answer the teachers' questions in class.
101. It's very important to me that I don't look stupid in my classes.
102. An important reason why I do my school work is because I like to learn new things.
103. An important reason I do my school work is so that I don't embarrass myself.
104. I like school work best when it really makes me think.
105. I'd like to show my teachers that I'm smarter than the other students in my class.
106. An important reason why I do my school work is because I want to get better at it.
107. I would feel successful in school if I did better than most of the other students.
108. The reason I do my school work is so my teachers don't think I know less than others.
109. Doing better than other students in school is important to me.
110. One of my main goals is to avoid looking like I can't do my work.

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**(Motivation: in versions 2, 4.)**

Using the scale below, indicate to what extent each of Items 111. - 120. presently corresponds to one of the reasons why you are going to CÉGEP.

**1. Strongly disagree 2. Disagree 3. Neither agree nor disagree 4. Agree 5. Strongly agree**

111. Because I will feel important when I succeed in CÉGEP.
112. Because I experience pleasure and satisfaction while learning new things.
113. Because I think that a CÉGEP education will help me prepare better for the career I have chosen.
114. Honestly, I don't know; I really feel that I am wasting my time in school.
115. In order to obtain a more prestigious job later on.
116. For the pleasure that I experience in broadening my knowledge about subjects which appeal to me.
117. Because eventually it will enable me to enter the job market in a field that I like.
118. I can't see why I am going to CÉGEP and frankly, I couldn't care less.
119. Because with only a high-school diploma I would not find a high-paying job later on.
120. To show myself that I am an intelligent person.

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**(Self-esteem: in version 2.)**

Items 121. - 130. below are statements dealing with your general feelings about yourself. Please rank them on the following scale:

**1. Strongly disagree 2. Disagree 3. Neither agree nor disagree 4. Agree 5. Strongly agree**

121. I feel that I am a person as worthy as anyone else.
122. I feel that I have a number of good qualities.
123. I am inclined to feel that I am a failure.
124. I am able to do things as well as other people.
125. I feel that I do not have much to be proud of.
126. I have a positive attitude towards myself.
127. On the whole, I am satisfied with myself.
128. I wish I could have more respect for myself.
129. I certainly feel useless at times.
130. At times I think that I am no good at all.

# Appendix C: University Certificate of Ethics Approval