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Academic Mentoring and Dropout Prevention for Students in Math, Science and Technology

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In this study, we examined the impact of a new academic mentoring program aimed at preventing student dropout in math, science and technology. The MIRES program entails bimonthly meetings between students entering college and university students completing their undergraduate degree in science and engineering. A randomized pretest-posttest control group design was used to evaluate the program’s short-term impact. At the end of the program, mentees (n = 150) presented significantly higher levels of motivation, a more positive career decision profile and enhanced institutional attachment and social adjustment than students in the control group (n = 157). MIRES mentees also showed success and persistence rates (mainly male participants) that were significantly higher than those of students in the control group.

Keywords: academic mentoring, college adjustment, science students, college, career decision

Integration and perseverance issues experienced by students in mathematics, science and technology (MST) programs represent an important challenge in postsecondary education in Canada and the United States. Nearly two out of five young people admitted into these programs at the college or university level will fail to graduate in this field (Quebec Ministry of Education and...
Leisure, 2008; Seymour & Hewitt, 1997). This situation has significant social and economic consequences given the growing number of jobs in MST and the lack of highly qualified labor. For example, it is estimated that by 2016, the province of Quebec will need to fill 1.3 million jobs (with a population of approximately 7.5 million residents), with close to 55% requiring a college or university degree in MST (Emploi-Québec, 2008).

As a result, many postsecondary establishments have implemented mentoring programs aimed at promoting young people’s interest in MST (Science Mentoring Research, 2009). However, the vast majority of these programs have not been systematically evaluated. For those that were evaluated, findings are limited by a number of factors: Absence of a validated theoretical framework, which poses limits on program development, on the specific focus of evaluation and on the knowledge base that is used to emit hypotheses; small sample sizes; absence of randomized control designs involving control groups; and a lack of attention paid to the empirical evidence on college persistence. The main objective of our present study was to evaluate the short-term impact of one such program known as the MIRES program (Mentoring for the Integration and Success of Science Students) while attempting to meaningfully address the limits that characterize this type of research. The MIRES program was implemented in two colleges in the Quebec City area, with the aim of helping students persevere within MST programs. In the current study, we examine the effect of this program on student academic integration, success and persistence.

Factors Related to Perseverance in MST

Beyond the family’s socio-economic conditions and the child’s history of success or failure—particularly in mathematics (Ma & Johnson, 2008)—a wide array of motivational, vocational, and academic factors are related to a student’s decision to abandon MST studies (Seymour & Hewitt, 1997). In this study, we addressed the factors that are most likely to be influenced by a mentoring intervention.

Low academic self-efficacy, involvement and interest, as well as a lack of value and importance given to scientific disciplines have been identified as motivational factors associated with youth dropping out of MST programs (Watt & Eccles, 2008). For instance, math and science self-efficacy beliefs were found to predict math-related career choices above and beyond current or past performance in mathematics (Ma & Johnson, 2008). In addition, a self-determined profile of motivation toward science (when a student is selecting science for intrinsic reasons such as for the pleasure and satisfaction of learning new things or for the social value attached to this particular option) was found to predict perseverance in college MST programs beyond high school achievement in science and parental socioeconomic
status (Ratelle, Larose, Guay, & Senécal, 2005). More importantly, some researchers have suggested that these motivational characteristics can be modified through targeted intervention with college students (see Luzzo et al., 1999).

Certain vocational factors also seem to play a role in a student’s decision to abandon MST studies. The discrepancy between the student’s interests, aspirations and personal needs and the profile required by work environments in the MST sector predicted dropout from MST programs, especially among women (Schaefers, Epperson, & Nauta, 1997). Career indecision and the anxiety associated with this indecision are additional factors that predicted the lack of perseverance in MST programs for both men and women (Larose et al., 2005). Finally, career aspirations in MST programs during adolescence have been identified as a good indicator of a student’s likelihood to occupy employment in an MST sector as an adult (Schoon, 2001).

The difficulty of adjusting to the MST teaching culture is another risk factor for dropping out of MST programs (Seymour & Hewitt, 1997). It has been suggested that many bright students leave science programs because of the: (a) strong emphasis on individual competition; (b) narrow syllabus content; (c) lack of consideration for practical applications; (d) abstract nature of the concepts presented in courses; (e) presence of gender stereotypes; and (f) use of curve grading as a frequently used strategy to weed out individuals (Seymour & Hewitt, 1997; Watt & Eccles, 2008). We believe that these negative aspects of the MST learning experience may reduce a student’s capacity for academic and institutional adjustment and, consequently, increase his/her risk of leaving the MST field before graduation.

Finally, low participation in extracurricular activities, such as science fairs, science clubs, museum and workplace visits, corporate internship programs and scientific conferences were found to decrease young people’s motivation in science and their persistence in MST (Barnes & Herr, 1998; Stake & Mares, 2001). These experiences are believed to enable youth to discover math and science principles in a hands-on social setting, which often deals with contemporary scientific issues. Moreover, they are thought to foster contact with professionals in the MST field. In fact, some researchers have shown that establishing meaningful bonds with an MST professional played a pivotal role in terms of generating interest in science (Hill, Pettus, & Hedin, 1990), especially among girls studying in traditionally male fields (i.e., engineering, computer science).

In sum, it is pertinent to examine the impact of the MIRES program in relation to four potential outcomes: Academic adjustment, career decision profile, student motivation to pursue MST studies, and perseverance. In the next section, we set out the foundations of mentoring research and present empirical studies on mentoring science students.
Formal Mentoring and Processes

Formal mentoring is defined as a supportive relationship between a more experienced person (the mentor) and a less experienced partner (the mentee), that enables the development of a trust-based relationship allowing for the needs of the mentee to be met (Eby et al., 2008). Mentoring is labeled as formal when the mentor is assigned and commits to following the structure set out in a given program (Ragins & Cotton, 1999). Formal mentoring may have different targets. For instance, it is known as youth mentoring when a child, teen or young adult is accompanied by an adult outside the family for various social and community activities. This form of mentoring is generally geared toward at-risk populations, its chief aim being to enhance the quality of bonding (DuBois & Karcher, 2005). It is known as academic mentoring when the support provided involves academic or vocational assistance from a teacher or other education-related individual (Jacobi, 1991). Finally, workplace mentoring involves a recognized workplace expert who accompanies a newcomer to help him or her integrate into and understand the culture of the new organization (Eby et al., 2008). The MIRES program is a formal academic mentoring program. It involves the pairing of students newly admitted into MST college programs (mentees: 16.7 years old) with university students completing their undergraduate degrees in science and engineering (mentors: 23 years old).

The MIRES intervention is based on the Sociomotivational Mentoring Model (Larose & Tarabulsy, 2005). This model was introduced to fill the knowledge gap regarding the role of mentor attitudes and behaviors on the development of their mentees. According to this model, four sets of mentor attitudes and behaviors are critical for improving youth social, academic, and vocational adjustment: (a) structure, (b) involvement, (c) autonomy support and (d) competence support. A mentor who establishes clear guidelines in terms of mentoring objectives, activities and functioning (structure), and who respectfully discusses personal, academic, and career issues with the mentee (involvement), is expected to develop a more positive relationship with his/her mentee. In the same way, a mentor who accepts and validates mentee’s personal choices without exercising any control or pressure (autonomy support) and who is able to increase the mentee’s feelings of competence following negative experiences (competence support) should also develop a positive relationship. This resulting positive relationship is believed to fulfill the mentee’s needs for competence, relatedness, and autonomy, thus leading to higher quality of social, academic, and vocational adjustment (Larose & Tarabulsy, 2005). Thus, this model suggests that mentoring programs that allow mentors to develop these groups of attitudes and behaviors improve the academic and vocational adjustment of their participants. Specific links between this model and the MIRES program are detailed in the method section.
Mentoring Science Students

A few rare studies have specifically addressed formal mentoring in MST programs. The most documented programs are e-mentoring programs that match female students with mentors working in industry (e.g., MentorNet) or those aimed at improving student-teacher relationships (e.g., the Research Careers for Minority Scholars mentoring program from the National Science Foundation, 1996). E-mentoring often entails just a few internet contacts per month and program evaluation is generally descriptive and rarely involves randomized comparisons between mentees and a control group (Miller & Griffiths, 2005).

In fact, we were able to identify only a single study pertaining to the impact of formal mentoring among MST students (Hedges & Mania-Farnell, 2002). This study compared the impact of three modalities—tutoring only, tutoring and mentoring, and no intervention—on the success levels of students enrolled in an introductory science course on anatomy and physiology. The tutoring only modality involved academic support given to a group of 6 to 8 students and offered by peers who successfully completed the course in the past (e.g., providing academic information, running problem-solving sessions, reviewing topics before exams). The tutoring and mentoring modality was different in that peers not only provided group tutoring, but also attempted to tailor the relationship with each student through a series of actions (e.g., calling students if they miss class; praising and encouraging students after exams; fostering student academic competence). After the intervention, the mentored students showed greater academic success than the two other groups, as measured by exam scores. However, although mentored students were more likely to complete the course than students who were not tutored, this difference was not statistically significant.

The Present Study

In sum, in spite of the proliferation of mentoring programs intended for science students, very few have been subjected to systematic evaluation. When evaluation is present, strategies are based mostly on retrospective methodologies which, by design, place certain limits as to the validity of findings. In addition, program evaluations of mentoring have rarely been grounded on theoretical models that account for the known predictors of mentoring effectiveness and program perseverance in MST.

Our study attempts to account for these limitations. It is hypothesized that participation in a mentoring program grounded in the basic premises of the Sociomotivational Mentoring Model and that takes into account the major determinants of success in MST will improve student integration and academic success in college. Specifically, students randomly assigned to the MIRES program will show greater levels of motivation in their science
studies, be better adjusted to college life, have a more positive career decision profile and show greater levels of success and perseverance in their science program than students randomly assigned to a control group condition.

**Method**

**Participants and Procedure**

The target sample for this study included all students newly admitted into science and technology programs in the fall of 2006 at two colleges in the Quebec City area. These students were all given the opportunity to register in the MIRES program. The majority of students admitted to MST programs (n = 659) in the fall of 2006 received a telephone call from our research assistants. The assistants congratulated them for being admitted into an MST program and informed them of the existence of the MIRES program and their eligibility to receive formal mentoring. After a brief presentation of the program and evaluation process, students were asked if they would be interested in eventually participating in the mentoring program. They were also told that the program would only accommodate 150 students for the current year and that if the number of volunteers exceeded 150, program participants would be selected at random. Three hundred and seven students expressed an interest in the mentoring program. Of that number, 150 were randomly assigned to the program (experimental group) and 157 to a control group (i.e., the regular academic path followed by first-year college students).

Eighty percent of the 307 participants were enrolled in natural science programs, 12% in a science and art program, and 8% were in computer science. Fifty-three percent were women and the average age was 16.7 years old (SD = 0.82). The mean grade for students entering these programs was 85% (SD = 5.56). A little over half of the students held part-time jobs (56%). Participants’ mothers had a mean annual income between $20,000 and $39,000, while their fathers earned between $45,000 and $55,000. The majority of fathers (82%) and mothers (78%) of participants had a postsecondary education. Almost all participants were born in Quebec (93%) and spoke French at home (98%). The majority of participants (98%) had never previously been exposed to mentoring.

Participants completed questionnaires relative to college adjustment, career decision and motivation at three different times: in August 2006, before the MIRES program began (Time 1), in December 2006 at the midpoint of the intervention (Time 2) and in April 2007 at the end of the second college semester (Time 3), which coincided with the end of the formal mentoring intervention. Success and retention in MST programs after one year in college were assessed from institutional data.
The MIRES Program

Content and structure

Mentors were recruited from Science and Engineering programs of the major university in the Quebec City area, Laval University. After an interview, mentors were selected based on their own previous experience in college, their previous experiences as mentors or tutors, and their ability to deal with relationship issues. They were assigned five students that they were to meet during the full academic year. At the onset of the study, we wished to match mentors and mentees that had attended the same college, been enrolled in the same program, had similar professional interests and be of the same sex. In effect, 72% of dyads were of the same sex and 50% of mentors had attended the same college as the mentees they were assigned to. In 2006, the program recruited 30 mentors—53% were women, 57% were undergraduate students and 43% were graduate students. Mentors came from a variety of university disciplines, such as computer science, physics, biology, microbiology and engineering. Their average age was 23 years old (SD = 2.73). Mentors received 150$CND per student per semester for their work with mentees.

Mentors underwent a two-day training seminar. Training focused on the problems generally encountered by students making the transition from high school to college, on university science programs and on the best individual practices in mentoring (e.g., expected frequencies of interactions and meetings, boundaries that define the nature and limits of the relationship [Campbell, 2007]). Mentor training continued throughout the intervention through two one-hour individual meetings (one per semester) and three two-hour small group meetings with supervisors (n = 8). Individual meetings served to address different issues and challenges raised during the mentoring process. Small group meetings were used to share experiences, strategies and pedagogical resources.

The MIRES program expected dyads to meet formally 16 times—once every other week throughout the academic year. The length of each meeting was expected to be approximately one hour. There are two reasons why 16 meetings were scheduled: First, it was important to provide enough time for the dyad to develop a working relationship and to establish mutual trust. Rhodes (2005) has shown that short-term mentoring programs (less than three months) are relatively ineffective in positively influencing youth development. Second, it was hoped that mentor input might help mentees address the challenges of the first two semesters in college. The first semester requires mentees to make social (form new social networks) and academic (meet expectations of professors and programs) adjustments. The second semester requires that mentees make program and course choices. During the meetings, mentors were encouraged to help their mentees explore science and technology programs, ask for help with their school work and exams when needed, clarify their academic interests and aspirations and
broaden their scientific literacy. The mentor training manual (Drouin et al., 2008) contained a list of potential themes and activities that mentors and mentees could engage in. Six major themes are described: (a) beginning a mentoring relationship; (b) integration into college and study program; (c) obstacles that are often encountered in courses and more generally as a student; (d) discussions on study program and career choices; (e) exploring program choices and career opportunities and (f) ending a mentoring relationship. In addition, the program counselors organized visits to research centers and industry in the Quebec City area. Examples of workplaces visited were: (a) a cancer research centre; (b) the department of food inspection at the Quebec Ministry of Agriculture and (c) a private business that hires programming analysts. Program expectations were that dyads participate in three two-hour educational visits during the school year.

**Theoretical approach**

The Sociomotivational mentoring model, presented earlier, inspired much of the work conducted within the MIRES Program. At least four aspects of the model can be found within the structure of MIRES, both in the training and supervision of mentors. First, mentors integrated the content and advantages of this theoretical model by reading a number of vulgarized scientific reports prior to initial training (see, Sections 5 and 8 of the Mentors’ Manual; Drouin et al., 2008). These reports present the model and operationalize the four specific skills that mentors are to target with mentees (Larose & Tarabulsy, 2005). For example, autonomy support is described as a set of specific behaviors, among which are: allowing the mentee to assume responsibility for actions; encourage mentees to take their own decisions; offer a variety of social and academic activities to allow mentees to make their own choices, based on their own interests.

Second, specifically designed video segments and case-studies were developed by program supervisors and used during the initial training to help mentors acquire abilities in these different areas. This training material was designed such that mentors in training could see both positive and negative mentoring practices. For example, one video vignette portrayed a relatively aloof mentor, not particularly involved with the mentee and quite directive in his attitude. As part of the training procedure, participants were asked to describe and qualify the mentor’s approach and the degree to which it corresponded to the theoretical model.

Third, both individual and group supervision enabled the consolidation of mentoring skills. During these meetings, supervisors specifically asked about difficulties encountered during mentoring meetings and about obstacles that prevented mentors from meaningfully addressing the four skills prescribed by the theoretical model. Supervisors and mentors worked together to elaborate strategies to address these different problems.
Finally, the different manifestations of the four skills were measured by mentors and mentees at four different times during the mentoring process with the Academic Mentoring Behavior Scale (AMBS; Soucy & Larose, 2004). The AMBS is a 12-item questionnaire which evaluates the four expected mentor competencies in line with the principles of the Mentoring Sociomotivational Model (Larose & Tarabulsy, 2005). The descriptive data collected from the AMBS strongly suggested that these competences were meaningfully addressed during the meetings. In fact, mentors and mentees reported means above 4.38 out of 5 (5 means that the competence was clearly expressed) for all scales (Emotional Involvement, Structure, Support of Competence and Autonomy Support) at each point of assessment.

**Outcome Measures**

**Motivation to pursue MST studies** was measured using the Academic Motivation Scale (AMS; Vallerand et al., 1993). This multidimensional scale measures five different types of reasons (five items each). Participants had to indicate, on a 7-point scale, the extent to which they pursue their studies out of Intrinsic Motivation (e.g., “For the pleasure and satisfaction of learning new things in this program”), Identified Regulation (e.g., “Because I think that this program will help me better prepare for the career I chose”), Introjected Regulation (e.g., “To prove to myself that I can succeed in this program”), External Regulation (e.g., “Because this program will allow me to get a lucrative job later”), and Amotivation (e.g., “Honestly, I don’t really know; I really have the impression that I’m wasting my time”). Previous studies have found high levels of reliability and validity for the AMS (see Vallerand et al., 1993). In our study, indices of internal consistency for the different subscales were acceptable, ranging from .76 to .92. In order to shorten the series of questionnaires, and as suggested by Ratelle, Guay, Vallerand, Larose and Senécal (2007), the Amotivation scale was not used in the present study since it specifically applies to high-risk populations. In addition the Introjected and External Regulation subscales were grouped to form the Controlled motivation subscale (Ratelle et al., 2007).

Students’ **career decision profile** was measured using the Career Decision Profile inventory (Jones, 1989). This instrument consists of 16 items, 4 of which are used to measure students’ levels of decisiveness (Decidedness: 2 items) and satisfaction with progress in making a career decision (Comfort: 2 items). The other 12 items refer to the need expressed by students to justify their level of uncertainty. More specifically, they measure their degree of Self-Clarity, Knowledge about Occupations and Training, Decisiveness and Career Choice Importance. Respondents must indicate whether they strongly disagree (1) or strongly agree (8) with each of the items. In the present study, high scores indicate a positive profile (i.e., high level of certainty and well-being, sound knowledge of Self and professional environments). The scale has been shown to have good internal
consistency and concurrent validity (Jones, 1989). In this study, Cronbach’s alphas ranged from .65 to .86.

Adjustment to college was assessed with the Student Adaptation to College Questionnaire (SACQ; Baker & Siryk, 1989). This measure uses a 9-point Likert scale ranging from doesn’t apply to me at all (1) to applies perfectly to me (9). It includes 67 items divided into four subscales. The Personal-Emotional Adjustment subscale pertains to the psychological and physical states of the student. The Social Adjustment subscale measures students’ success in coping with various aspects of the interpersonal-societal demands of college. The Academic Adjustment subscale assesses students’ adaptation to various educational demands of the college experience, and the Attachment to the Institution subscale measures the quality of the relationship or bond that is established between the student and the institution. The SACQ has high test-retest reliability and internal consistency and adequate construct and predictive validity (Baker & Siryk, 1989). In the present study, internal consistency coefficients varied from .61 through .92.

Academic success and persistence were assessed using the success and persistence rates after the first year of college. These data were provided by the two institutions attended by participants. Success rates were calculated based on the number of courses successfully completed out of the total number of courses taken. Students were deemed to be persistent when they registered in a math-, science or technology-oriented study program after the first year of college (i.e., physics program; biology program; science or science, art and literature), whether or not they changed programs. Students were defined as non-persistent when they left the MST program for any other program (e.g., humanities) or when they dropped out of college altogether.

Results

Preliminary Analyses
We first verified whether participant characteristics varied on the basis of their group—MIRES or control. Student t-tests and chi-Square tests indicated that the two groups did not vary in terms of socio-demographic and academic profiles (e.g., program, gender, high school average; t values varied from −.25 to −1.39, p > .05; \( \chi^2 \) values varied from .17 to 3.57, \( p > .05 \)). We also examined whether groups varied with respect to other support measures offered by colleges (other than the MIRES program). Five questions were asked at the end of the first and second semesters. These questions allowed us to identify the proportion of participants who received special one-on-one support from five possible sources: A learning centre, teacher, individual academic advisor, vocational counselor or a psychologist. Analyses using the chi-Square Test indicated that the proportion of students registered in the MIRES program who received support in college outside the scope of the program was similar to the proportion of students from the
control group. This was the case both in the first ($\chi^2$ values vary from .001 to 1.81, $p > .05$) and second ($\chi^2$ values vary from .02 to 1.71, $p > .05$) semesters when this potential confound was addressed.

**Integrity of the Intervention**

We also examined whether the mentoring program was applied in its integrity. Recall that the MIRES program entails 16 hours of formal meetings—one every two weeks—throughout the academic year and the participation of mentors and mentees in three two-hour educational visits with industry and/or research centers. Twelve percent of mentees mentioned having had fewer than 8 meetings during the academic year—53% had between 8 and 12 meetings and 35% reported having more than 13 (with the median being 13 meetings). These meetings lasted an average of 55 minutes. The percentage of young people who participated in three visits to a research centre or an industrial setting stood at 32%. Twenty-seven percent of mentees participated in two visits, 10% in one visit and 31% did not take part in any visits. Although exposure was less than that prescribed by the program, we followed a conservative approach and included all students in the experimental group in the analyses presented in the next section.

Mentors were asked to complete a logbook after meetings. In addition to recording different information from mentoring meetings, this log comprised three Likert scales assessing how they had used their time with their mentees during a specific meeting: (a) discussing personal and academic issues (e.g., loneliness, academic interests); (b) carrying out a specific activity (e.g., academic conference, industrial visits) and (c) trying to solve a specific problem (e.g., exam preparation, tutoring in math and science). Likert scales comprised 5 points: 1 = not present to 5 = strongly present. They were also invited to indicate the nature of the interaction using four additional scales (social, academic, emotional, and vocational). The descriptive data revealed that dyads were primarily involved in discussions ($M = 4.43/5$) and that they spent less time in specific activities ($M = 2.30/5$) and resolving personal problems ($M = 2.14/5$). Most interactions dealt with academic program or career-based questions ($M = 3.59/5$: e.g., career or program choices) or emotional issues ($M = 3.44/5$: e.g., loneliness or feelings of incompetence). Specific problems with courses ($M = 2.72/5$: e.g., difficulties in a specific class) or social problems ($M = 2.25/5$: e.g., making new friends) were less often discussed.

**Impact of the MIRES Program on College Integration Indicators**

To evaluate the impact of the MIRES program on motivation, career decision profile and college adjustment, we conducted a series of multivariate analyses of covariance (MANCOVAs) (F)—followed by univariate analyses of covariance (ANCOVAs)—on data gathered midway through the program and at the end, while covarying the pretest data. Through these analyses we
were able to compare average scores of mentees and those of control group participants during the intervention (Time 2) and at the end of it (Time 3), while ensuring that variations were not attributable to differences that existed before the implementation of the program (Time 1).

Table 1 presents descriptive statistics (adjusted means, standard deviations, and effect sizes) of college integration indicators. Multivariate analyses conducted on motivation indicators showed no differences between the groups at Time 2 ($F(3, 296) = 0.55, \text{n.s}$). However, differences emerged at Time 3 ($F(3, 294) = 2.85, p < .05$). At the end of the program, mentees were found to have significantly higher levels of Intrinsic Motivation ($F(1, 298) = 7.60, p < .05$), and Identified Motivation to pursue MST studies ($F(1, 298) = 8.29, p < .01$), than their control group counterparts. In other words, the decision to study in MST programs was motivated to a greater extent by pleasure, interest in and value given to these areas of study. No difference was found between the groups regarding the level of controlled motivation.

In terms of the career decision profile, multivariate analyses indicated differences between groups at Time 2 ($F(6, 289) = 2.56, p < .05$), and Time 3 ($F(6, 285) = 2.62, p < .05$). Midway through the program, mentees were more decisive about their career choice ($F(1, 294) = 4.25, p < .05$), were more comfortable with indecision ($F(1, 294) = 4.29, p < .05$), had a better understanding of their interests and skills ($F(1, 294) = 4.58, p < .05$), and had better knowledge of MST study programs and careers ($F(1, 294) = 5.13, p < .05$). Many of these differences were also observed at the end of the program. Mentees remained more comfortable with indecision ($F(1, 290) = 4.02, p < .05$), had a better understanding of their interests and skills ($F(1, 290) = 4.25, p < .05$), and had better knowledge of MST study programs and careers ($F(1, 290) = 5.66, p < .05$), than did students in the control group. However, no differences were found regarding levels of Decisiveness and Career Choice Importance.

The MIRES program also had positive effects on college adjustment. No differences were found between both groups at Time 2 ($F(4, 297) = 1.61, \text{n.s}$), but emerged at Time 3($F(4, 294) = 3.29, p < .05$). At the end of the intervention, mentees perceived their social adjustment ($F(1, 300) = 3.21, p < .05$), and institutional attachment ($F(1, 300) = 4.01, p < .05$) in a more positive light than did control group participants. However, academic and emotional adjustment levels were relatively similar among participants in both groups throughout the year.

A Cohen’s d calculation suggested that the effect sizes on the college integration indicators were generally small ($< .25$), but consistent with those found in meta-analyses on mentoring (Eby et al., 2008). This assessment also indicated that the most significant effect sizes were noted at Time 3, at the end of the program, on the Identified Motivation, Knowledge of Careers and Programs and Attachment subscales.
Table 1
Adjusted Means, Standard Deviations, and Effect Sizes for Motivation, Career Profile and College Adjustment

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<tr>
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<th>Mentees (n=150)</th>
<th>Controls (n=157)</th>
<th>Effect sizes</th>
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<td>T2 M</td>
<td>SD</td>
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<tr>
<td>Knowledge about</td>
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<tr>
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<td>1.60</td>
<td>4.76</td>
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<td>1.79</td>
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<td>Career choice</td>
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<tr>
<td>Attachment</td>
<td>7.43</td>
<td>1.12</td>
<td>7.78</td>
</tr>
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Notes. T2: after the mid-point of the intervention; T3: at the end of the MIRES program. Mean scores at Time 1 were used as covariates in analyzing the Time 2 and Time 3 group differences. Potential ranges for the motivation, career decision profile, and college adjustment outcomes are 1–7, 1–8, and 1–9 respectively.
Impact of the MIRES Program on Academic Success and Perseverance

We performed contingency analyses to determine if the proportion of students who successfully completed all their courses (100% success rate), a majority of the courses (between 60 and 90%) or a minority of their courses (less than 60%) were similar across groups after one academic year. The same analyses were conducted on the academic persistence variable, and again we distinguished between students still registered in an MST program after their first year (persistent group) from those who selected another program unrelated to the MST field (e.g., humanities) or who dropped out of college (non-persistent group). The two last groups were divided into students who left MST programs after the first semester and those who left after the first year.

In the fall of 2006, a greater number of mentees had successfully completed all their courses (80% vs. 68%), and were less likely to have failed more than 40% of their courses (1% vs. 10%) ($\chi^2 (2) = 11.3, p < .05$). These differences did not exist in winter 2007, however, since the proportion of students for each of the categories were similar in both groups ($\chi^2 (2) = 0.01$, n.s.). In terms of persistence, mentees of the MIRES program were more likely to persist than control group participants ($\chi^2(2)=6.27$, $p < .05$). In fact, 86% of mentees stayed in MST after one year, versus 76% among the control group. Among students who left MST, 6% of mentees did so after one semester (compared to 14% among control group participants) and 8% left after two semesters (compared to 10% among control group participants).

Gender Differences Analyses

In light of the attention given to gender differences in the study of MST enrollment and persistence (Ceci & Williams, 2007) potential mentee and mentor gender contributions to the MIRES program effectiveness were explored. Some researchers suggested that reasons for participating in, and expectations towards, mentoring programs may be different for boys and girls (Campbell, 2007). Such differences may be associated to participant motivation, career decision profile or college adjustment and success.

To address this possibility, the same MANCOVAs and contingency analyses were conducted with participant gender as an additional factor. To examine the impact of mentor gender, three categories were created (1: male mentor; 2: female mentor; 3: no mentor) and two constrasts were tested (1–2 vs. 3; 1 vs. 2). Results revealed no mentor and student gender effects on motivation, career profile, and college adjustment. $F$ values ranged between .00 and 1.32 and all $p$ values were well above .05. Thus, it appears that MIRES program effects on these outcomes are similar for male or female students, regardless of whether they were matched with a male or female mentor. Contingency analyses on the proportion of classes passed during the first school year also
show an absence of gender effects on MIRES program effectiveness ($\chi^2$ varies between .35 and 1.22 and all $p$ values are above .05).

Student gender effects were found, however, with regard to perseverance. Two $2 \times 2$ chi-square tests of independence (perseverance by condition) within student gender revealed a significant association for male ($\chi^2(1) = 7.15, p < .01$) but not for female ($\chi^2(1) = 1.27$, n.s.) students. The rate of male mentee perseverance was 89%, compared to 70% for male control group participants, whereas these rates were 85% and 82% respectively for female participants. These differences were independent of the gender of the mentor as revealed by the non-significant associations found between perseverance group and condition for both female ($\chi^2(1) = 1.11$, n.s) and male mentors ($\chi^2(1) = 0.67$, n.s). Thus, the MIRES program appears to have a more important effect on perseverance for male rather than female students.

**Discussion**

In spite of the growing interest in formal mentoring programs on the part of many college-level institutions in many countries (e.g., Australia, New Zealand, Canada, United States, Israel), the rigorous evaluation of programs implemented by such institutions remains the exception rather than the rule. Our study suggested that an academic mentoring program that takes into account knowledge of the determinants of the decision to abandon MST programs, and that is grounded in a promising theoretical mentoring model (Larose & Tarabulsy, 2005) can facilitate academic integration and persistence among youth interested in these fields of study. More specifically, we showed that participation in the MIRES programs had positive effects on motivation (value and pleasure associated with MST studies), career decision profile (decidedness, comfort, self-clarity and knowledge of the field), college adjustment (institutional attachment and social adjustment) and academic success and persistence of students (mainly male participants). These effects were relatively small, but correspond to findings reported in meta-analyses on the impact of mentoring (Eby et al., 2008). They suggested that academic and vocational mentoring is useful in enhancing motivation for MST careers and preventing students from dropping out from this field. A unique feature of our study is that it measured the effects of mentoring midway through and at the end of the intervention. MIRES mentoring lasted one academic year. After the first semester, positive effects of the intervention on several student career decision profile indicators were reported, as was the case with success and persistence rates. However, effects on academic motivation and college adjustment were noted only at the end of the intervention.

To begin, the program’s positive impact on success rates during the first semester is very good news. Success during the first semester in college is often considered an important determinant of academic persistence and
graduation (Seymour & Hewitt, 1997). Successfully completing first-semester science courses may boost student confidence, reduce anxiety and lessen the anticipation of failure often associated with these courses, and may also reassure students as to their abilities to pursue MST studies. As is suggested in the Mentoring Sociomotivational Model (Larose & Tarabulsy, 2005), mentors may have played a role in the success of mentees by promoting their competence and autonomy throughout the semester, providing them with concrete, visible support (e.g., help with exam preparation, organization of a student-teacher meeting, teaching study techniques) and by helping them to set short- and long-term goals. An unexpected finding of our study is that mentoring impacted student academic success during the first semester without, however, having an effect on academic adjustment. One interpretation of this result is that early success of MIRES participants is due to progress made on the vocational rather than the learning front.

This possibility is supported by the presence of short-term effects of the MIRES program on students’ career decision profiles. MIRES participants were quick to consolidate their decision to pursue a career in MST and felt comfortable with this decision. Concurrently, and coherently, students reported a higher level of self-clarity and knowledge about training programs and professions. Open and respectful discussions between the mentor and the mentee about career issues and mentee scientific visits in workplace settings may have helped mentees reflect on who they are, what they want to be and do and the best way to reach that goal.

Effects on social adjustment and institutional attachment were found only at the end of the intervention. One hypothesis that may explain this finding is that changes in these variables may derive from long-term rather than short-term mentoring processes. For example, social adjustment and institutional attachment involve initiating new relationships with peers and teachers in college, assessing the relevance of these relationships for social development and consolidating those deemed more relevant in terms of reaching personal goals. These processes require time and many mentoring meetings are probably needed before change in the quality of social and institutional adjustment may be accomplished. Likewise, effects on intrinsic and identified motivation were noted at the end of the program. These types of motivation imply that the students enjoy what they are learning and perceive it as useful for attaining their personal and professional goals. Mentoring during a single semester may not be sufficient to allow students to clearly express their values and goals. The critical aspect of these findings is that they provide support for the basic premises of the Mentoring Sociomotivational Model (Larose & Tarabulsy, 2005) in which a structured and committed mentoring relationship, oriented towards providing autonomy and competency support, is presented as a condition for the improvement in the quality of social development.
Effect sizes suggested that the type of mentoring examined in the present study had a greater impact on some variables rather than others. Identified motivation, knowledge about study programs and institutional attachment were more strongly influenced by mentoring, while academic and emotional adjustment and the importance given by youth to career choices were less affected. On the one hand, the vocational orientation of the mentoring program under study herein most certainly explains these findings. Interventions by mentors aimed mainly at questioning and consolidating students’ decision to pursue studies and a career in MST and exposing them to exploratory activities within their institution (e.g., using employment resources at the career and orientation centre; meeting a teacher) and outside of their institution (e.g., visiting industrial settings and research centers; attending a university course). These interventions may have had a direct impact on the perceived usefulness of MST studies (identified motivation), knowledge of jobs and study programs in this field and institutional attachment. Regarding this last variable, many mentors (50%) had attended the same establishment as their mentee during their college studies and this may have contributed to the quality of the student’s institutional attachment.

On the other hand, the lack of program effect on academic and personal-emotional adjustment may be due to the type of clientele who participated in the present study. As is indicated by the overall mean in high school obtained by participants ($M = 85\%$), the mentoring program was offered to students who already had good academic standing. Academic and emotional adjustments were probably not an important issue in terms of their transition to college. Otherwise, the absence of effect on importance given to career decision by youth may be explained by a ceiling effect. Participants most positively evaluated this dimension on the whole at the onset of the study. It may be more difficult to improve something already perceived in a very positive light by most participants.

The MIRES program had a greater impact on the perseverance of male, rather than female students. It is possible that the kind of academic and vocational mentoring that takes place within the MIRES program addresses concerns that are more directly related to short term, male student preoccupations and needs. This possibility is supported by research on workplace mentoring suggesting that male students require more instrumental and career support than do female students, whereas the latter seek greater levels of socioemotional support (Allen & Eby, 2004). The kinds of activities that take place within the MIRES program (e.g., discussions on study programs, careers, institutional visits, tutoring) are perhaps more geared toward providing the instrumental support that males seek in such contexts. It is possible also that short-term program effects on female student perseverance are more difficult to tease out because female college students are generally less academically at-risk than male students. Whatever the explanation for this finding, it is critical to bear in mind that all other MIRES program effects
(motivation, career decision profile, college adjustment) were unrelated to student gender. These may be viewed as setting conditions for program perseverance. Thus, it is possible that the observed short-term effects on these dimensions may contribute to female student perseverance, but only after a longer period of time has elapsed, for example, during the transition to university. Such interpretations underline the importance of measuring the impact of mentoring on university admission and graduation rates as a function of student gender. Academic trajectories may be modified at different times for males and females, and it is only by assessing the long term impact of mentoring that it will be possible to determine its differential effectiveness.

Thus, from our study we suggest that formal mentoring during the first year of college can generate positive effects on the social and vocational adjustment of youth interested in pursuing an education and a career in MST-related fields, as well as on their academic motivation, success and perseverance. The research design used in our study (randomized control group), the evaluations held midway through and at the end of the intervention, the control of academic support during the academic year and the use of subjective (e.g., motivation) and objective (e.g., success rate) criteria to measure the effects of mentoring represent the strengths of our study. Our study also features limitations, however. The characteristics of the target participants (a low-risk student sample), the limited number of mentors (30) and the absence of external evaluations from mentors and teachers are factors that limit the external validity of the study.

Many college institutions around the world are faced with alarming MST program dropout rates and countries must deal with the economic consequences that these rates entail (Seymour & Hewitt, 1997; Watt & Eccles, 2008). The findings of our study suggest that academic and vocational mentoring constitutes an effective measure in encouraging a greater number of college students to pursue studies in this field. In line with recent scientific work on effective mentoring practice (Campbell, 2007), our study also suggests that certain conditions must be adhered to in order for mentoring programs to be effective: Providing initial training and supervision to mentors, matching mentors and mentees based on similar personal and professional interests, encouraging mentors to become involved in social, cultural or scientific activities with their mentees, ensure that programs are devised and implemented as a function of solid empirical knowledge of student characteristics (in the present case, this knowledge base came largely from research on the high-school-college transition and on factors related to MST program perseverance), and structure mentor training and supervision based on theoretical approaches that have been validated or are in the process of being validated (in the present case, the Sociomotivational Mentoring Model).

Finally, it is conceivable that this type of mentoring program may provide yet another tool for addressing the specific problem of male college
perseverance in MST programs, and perhaps other programs. During late adolescence and early adulthood, males are more often hesitant to access the help services offered by academic institutions. The peer mentoring that is offered in the context of a program such as MIRES may address in a more precise way the specific academic challenges and need for autonomy that these young men face. The absence of a perseverance effect for young women suggests that further adjustments may be brought to the program to address the specific needs of this segment of the college MST population.

References


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