STUDENT RETENTION AND ACADEMIC SUCCESS IN POSTSECONDARY SCIENCE STUDIES

RESEARCH PROGRAM ON STUDENT RETENTION AND ACADEMIC SUCCESS

Québec

SUMMARY OF TWO RESEARCH STUDIES FINANCED AS PART OF THE RESEARCH PROGRAM ON STUDENT RETENTION AND ACADEMIC SUCCESS (MELS-FQRSC)

- Student Retention in Science and Engineering at Université Laval
- Academic Success and Student Retention in the Sciences in English CEGEPs

STUDENT RETENTION AND ACADEMIC SUCCESS
IN POSTSECONDARY SCIENCE STUDIES

Québec is experiencing an increasing need for labour specialized in science and technology, yet many students currently in these fields are having difficulties that sometimes cause them to leave their programs. Québec researchers have been studying and documenting various aspects of this issue with a view to identifying possible solutions.

Since 2002, the Ministère de l'Éducation, du Loisir et du Sport (MELS) has been supporting the Research Program on Student Retention and Academic Success (RPSRA), which has provided funding to a number of studies dealing with the theme of tomorrow's specialized science and technology labour force. This document summarizes the findings of two research studies on student retention and academic success in science and technology programs that were conducted in a university and in a college setting.

UNIVERSITÉ LAVAL AND ENGLISH CEGEPS

The first research study[1] is a longitudinal and comparative study started in 2003 with students enrolled in science and engineering at Université Laval. The research findings show that, contrary to what one might think, student retention in these fields is related less to prior academic achievement and acquired knowledge than to a set of personal and social factors underlying a student's academic and career choices.

The second research study[2] focuses on the factors likely to influence academic success and student retention in college science programs. The findings of this study show that secondary school graduates do not decide whether or not to continue their science studies in college on the basis of their aptitudes and academic achievement. The study also documented a number of teaching methods, some of which focus on the transfer of knowledge and others on creating an environment that promotes learning. It was found that the latter tend to foster student retention in science programs, for both male and female students.

FROM KNOWLEDGE TO ACTION

The key points of each of the two studies are presented below: the research background, the hypotheses, the methodology, the results as well as the conclusions and recommendations. The last section of this document considers the main findings of the two studies together, with a view to highlighting the commonalities in the possible avenues for reflection and action.

1. Simon Larose et al., *Persévérance scolaire des étudiants de sciences et génie (S&G) à l'Université Laval. Le rôle de la culture, motivation et socialisation scientifiques* (Montréal: Université Laval, Groupe de recherche sur l'inadaptation psychosociale chez l'enfant [GRIP], 2005), <http://www.fqrsc.gouv.qc.ca/recherche/pdf/RF-SimonLarose.pdf/>. Study financed as part of the Research Program on Student Retention and Academic Success (MELS-FQRSC).
2. Steven Rosenfield et al., *Study of Factors That Influence The Success and Perseverance in Science Programs in Anglophone CEGEPs* (Montréal: Vanier College, 2005), <http://sun4.vaniercollege.qc.ca/fqrsc/>. Study financed as part of the Research Program on Student Retention and Academic Success (MELS-FQRSC).

STUDENT RETENTION IN SCIENCE AND ENGINEERING AT UNIVERSITÉ LAVAL

A high failure and dropout rate has been observed in postsecondary science and technology programs for more than ten years. Past research indicates that nearly 30% of students leave a college science program before completing it. MELS data also indicates that nearly 40% of undergraduate university students in science and engineering or pure and applied science have still not earned their degree six years after they first enrolled in these programs. In order to improve student retention in these fields, a team of researchers at Université Laval, under the direction of Professor Simon Larose, has been working to pinpoint the factors that motivate students in these fields to continue their studies.

In 2003, the team began a research program whose specific objectives were to describe the culture of students newly enrolled in science and engineering programs at Université Laval, to assess the impact of this culture on student retention, and to determine how the impact of cultural factors varies according to gender and program of study.

Professor Larose's team adopted a systemic approach and an original model developed specifically for this study: a sociomotivational model of student retention in science and technology. According to this model, students enroll and stay in science and technology programs because they are motivated to learn about science; this motivation is instilled when individuals have meaningful interactions with their social, school and work environments. The model also takes into account the socioeconomic context of individual paths. In other words, the researchers attempted to identify the factors that promote student retention, beyond academic performance and acquired knowledge, in order to clarify the types of intervention that would increase student retention. Table 1 presents elements related to the research hypotheses stemming from the sociomotivational model.

TABLE 1

Factors fostering student retention of new enrollments in science and engineering programs at Université Laval, by category (personal motivation and various contexts)

PERSONAL MOTIVATION	FAMILY CONTEXT	SCHOOL CONTEXT	EXTRACURRICULAR CONTEXT
• Self-efficacy in college science courses • Attachment to peers and to college science or technology programs • Strong determination to study science and engineering	• Family environment supportive of science education (books, computer, science-related activities, etc.) • Parents involved in science education	• Open and supportive science and mathematics teachers in college	• Participation in meaningful science-related activities

Methodology

Phase 1. – In the autumn of 2003, during the first week of classes, researchers visited classrooms to ask students to voluntarily participate in the survey. The questionnaires covered general knowledge of science, culture, science motivation and scientific socialization, as well as the sociodemographic profile of the respondent. A total of 489 questionnaires were distributed.

The resulting sample was broken down as follows: 23% of students were in the applied sciences (actuarial science, statistics, computer science); 38% in the pure sciences (biochemistry, microbiology, biology, chemistry, geology, mathematics and physics); and 39% in engineering (physical, chemical, materials, mining, electrical, computer, geological, software, mechanical and civil). Some 62% of the students in the sample were male. With respect to the parents of participating students, 42% of the fathers and 30% of the mothers had begun or completed university studies.

Phase 2. – In the winter of 2005, researchers conducted 407 telephone interviews lasting approximately 15 minutes in order to determine the paths followed by the students since Phase 1. These same students were also asked to complete a questionnaire and return it by mail. A total of 337 duly completed questionnaires were received.

Lastly, the registrar's office at Université Laval provided complementary data on students who either changed programs or dropped out.

SOCIOMOTIVATIONAL PROFILE AND STUDENT RETENTION

Research findings can be broken down into three categories: the sociomotivational profile of students enrolled in the autumn of 2003; student retention factors related to the sociomotivational profile; and the variability of the correlation between profile and student retention by gender and program of study.

Sociomotivational profile

Generally, the sociomotivational profile of students at the beginning of their science and engineering studies in university was very positive. The profile of students in the applied sciences, however, differed slightly from that of other students: their scientific knowledge was not as extensive, they took part in informal science education activities less frequently than other students, their choice of field of study was based more on the associated socioeconomic advantages, and they did not enjoy college laboratory activities as much. Proportionally, many more male students were enrolled in the applied sciences (78% of the sample) than in the pure sciences (41% of the sample), which could in part account for the differences observed in terms of the science knowledge, culture and motivation of students in these fields.

Overall, the female students in the sample had a more positive profile than the male students. They considered themselves more competent in science, were more certain of their choice of program, were more involved in their college science studies, more positively evaluated the support they received from their parents and their college teachers' instructional approach, and gave less credence to stereotypes that deny the place of women in science and engineering. Such a profile tends to challenge the notion that society stifles women's interest in the sciences and their commitment to the field.

Although the students' sociomotivational profile was very positive overall, appreciable individual differences were observed for each profile category. The following section examines the correlation between these differences and the students' decision of whether or not to continue their studies.

Student retention factors

Two years after starting university, 81% of the students in the sample were still in a science and engineering program (Figure 1), whereas 19% had left these programs.

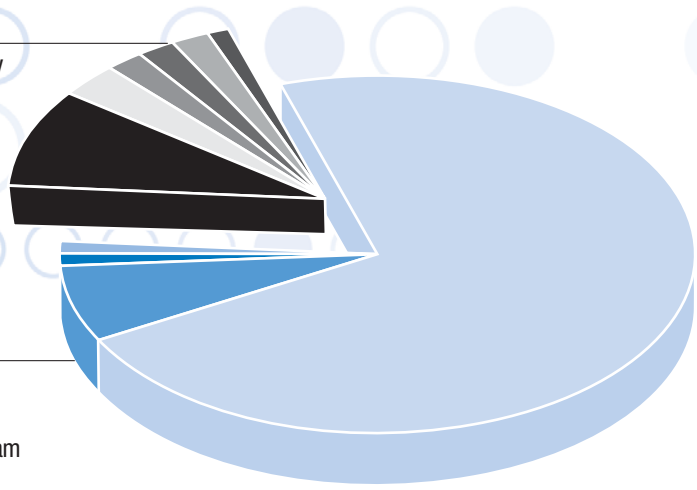
Statistical analyses show that student retention varied significantly according to eight variables: field of study, the student's age, the salary for the job occupied in the last six months, the choice of program upon admission, place of residence, presence of siblings having taken college science courses, participation in the welcome day organized by the faculty of science and engineering in the spring of 2003, and subscription to scientific journals.

Thus, the lowest retention rate was observed for students in the applied sciences, for whom motivators such as salary and social recognition are extrinsic. Older students, who have more financial and family (children) responsibilities, had lower retention rates than younger students. Students whose first choice was not a science and engineering program were less likely to pursue their studies. Students with brothers and sisters who studied science in college were more likely to continue in their science and engineering program. Those who participated with their parents in the welcome day organized by the faculty of science and engineering showed a much higher retention rate than those who did not and those who came without their parents. Very few students in the sample subscribed to scientific journals, but those who did had a higher retention rate.

Among the other variables associated with student retention in science and engineering after two years of study, the most significant was that of career choice. The students who were the most confident about their career choice were more likely to pursue their studies than those who were less certain. The students who participated in science activities outside of school and who regularly discussed scientific issues and controversies were also more numerous in continuing their studies. Similarly, students who

FIGURE 1

Student retention of science and engineering enrollments (after two years of university)



remained in school tended to place more value on knowledge, were less likely to suffer from a lack of motivation, and were more involved in their college studies than students who had left their science and engineering program. A mother's higher level of education was also a factor of student retention. The students who were pursuing their science and engineering studies reported having earned higher marks in college mathematics courses than students who were not. However, academic achievement was generally less of a factor in the variation in student retention than several other factors related to motivation and scientific culture.

Finally, such variables as parental socioeconomic status, student gender and self-efficacy in mathematics, science and French were not related to student retention in science and engineering. The lack of correlation between student retention and self-efficacy in mathematics and science may be surprising, especially since the researchers observed the opposite in college students. This finding may be explained by the fact that while students' feeling of competence remains relatively unchanged when they first enroll in science and engineering programs, this could change during the program.

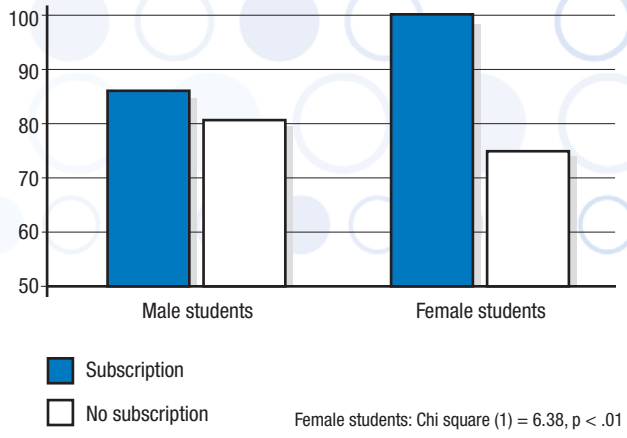
Variability of the correlation between profile and student retention by gender and program of study

Student gender had a moderating effect on certain variables. For example, female students who took part in scientific cultural visits and in science-related activities outside of school, who discussed scientific issues and controversies and who subscribed to scientific journals were much more likely than male students to pursue their science and engineering studies.

Subscribing to scientific journals was a particularly significant factor. All the female students (Figure 2) who subscribed to these journals were continuing their science and engineering program, whereas the student retention rate was 75% for those who did not. In the case of male students, however, the fact of subscribing to scientific journals appeared to have little effect on their retention rate. These findings lead researchers to believe that female students have more of a need than male students to be in some way involved with the scientific profession in order to maintain their motivation to persevere in their chosen field.

FIGURE 2

Subscription to scientific journals and retention rate



Female students: Chi square (1) = 6.38, $p < .01$

With respect to the program of study, students who were continuing their studies in the pure sciences were more certain of their career choice than those who were not. In the applied sciences, career choice certainty did not appear to be related to student retention, perhaps because the professional destination is less defined in applied science programs and because students in these programs decide on their specific career track in the course of their training.

RECOMMENDATIONS

Based on the main findings of their study, the researchers conclude their report with recommendations that concern colleges, universities and parents.

Given that student retention in science and engineering is not based solely on good academic results and subject-specific knowledge, program directors need to be encouraged to take initiatives outside the school setting. Such initiatives could include pursuing and intensifying career and science exploration activities and encouraging students to read popular scientific journals. Female students should be especially encouraged to take part in these activities as they appear to derive more benefit from them than their male peers. Practices should be adopted that help students develop feelings of self-determination and attachment to school. Older students, especially those with family responsibilities, as well as students in the applied sciences should be more closely monitored because their motivation appears to be less related to student retention than that of students in the pure sciences. Lastly, parental participation in welcome and integration activities seems to have a positive impact and should therefore be encouraged.

ACADEMIC SUCCESS AND STUDENT RETENTION IN THE SCIENCES
IN ENGLISH CEGEPS

The report of Professor Steven Rosenfield's team begins by pointing out that students' interest in science has declined considerably in Québec over the past two decades. Also, women and ethnic minorities are underrepresented among science program graduates. Of even greater concern is the fact that an ever-growing number of students in science programs in developed countries are graduating with a superficial rather than in-depth knowledge of science. Rosenfield's team is supposing that Québec's situation is consistent with the results of international studies.

These problems may be due to the fact that rather than draw inspiration from research on science instruction carried out over the past 20 or 30 years, teachers tend to teach their courses according to their own perceptions and beliefs. This research indicates that the learning context is critical for science education. It is even more important to take into account individual backgrounds and characteristics when teaching science to female students and ethnic minorities. The findings are also consistent with what the students themselves say they expect, that is, an interactive approach to teaching that turns learning into a process of discovery in which concepts are related to one another and to the real world.

In this context, the objective of Rosenfield's study was to better understand how different perceptions of the learning environment interact with students' characteristics to influence student retention and academic success in science studies.

Theoretical perspective

Students and teachers are influenced by their beliefs, perceptions and conceptions. Students learn differently when taught by different teachers, not only because different teachers are more or less skilled or know more or less content, but primarily because different teachers have different approaches to promoting learning.

After reviewing the frameworks for various conceptions of teaching, the researchers identified four distinct conceptions. These are presented in Table 2 together with a summary of their characteristics.

TABLE 2

Four conceptions of teaching in mathematics and science

1.	**Transmission of knowledge**	Accumulation of knowledge and transmission from generation to generation
2.	**Training skills**	Teaching focused on specific competencies and academic performance
3.	**Nurturing personal growth**	Emphasis by the teacher on the student's aptitudes and abilities
4.	**Fostering conceptual change**	The teacher as the instigator of a dialectic process through which students develop knowledge and beliefs

For each of these conceptions, the researchers developed a set of possible actions and activities for a teacher using that approach (preparation, delivery and assessment). They created a bank of reference actions that they then used to design the survey for CEGEP teachers. After pretesting the survey, conceptions 3 and 4 were combined and the framework was reduced to three conceptions: transmission of knowledge, training skills, and fostering understanding.

Methodology

The sample was comprised of 2 479 students (1 291 female students and 1 188 male students) who graduated from secondary school in June 2003 and enrolled in an English CEGEP in the autumn of the same year. Each individual participated in at least one of the three phases of the study conducted during the first four semesters of his or her college studies. Data was gathered using a questionnaire of approximately 100 items, including a sociodemographic section (age, gender, ethnic background, etc.) and rating scales for the different variables (interests, motivations, beliefs, self-efficacy, self-esteem, etc.). The questionnaires were completed in the classes of four English CEGEPs and some students completed a Web version of the survey.

Student retention and academic success were assessed using data from the MELS databases as well as the data gathered during the three phases of the study, between the autumn of 2003 and the spring of 2005.

The correlation between perception of the learning environment, on the one hand, and student retention and academic success, on the other—i.e. the focus of the study—was examined using a subset of 1 425 students (765 female students and 660 male students) from the 2 479 questionnaire respondents.

To determine teachers' perceptions of the learning environment, the researchers used a sample of 84 respondents, representing 42% of the science and mathematics teachers in the four participating CEGEPs. The questionnaire used to collect data in the winter of 2004 comprised 80 items, 30 of which dealt with perception of the learning environment in the classroom, teaching approaches and course preparation.

THE IMPACT OF PERCEPTION ON STUDENT RETENTION AND ACADEMIC SUCCESS

Perceptions of the learning environment

The data reveals that students perceived three main types of learning environments, each with a dominant characteristic: "fostering," "collaborative" or "transmitting."

While the teachers' perceptions were very similar to the students', the findings show that teachers classified learning environments into two main categories rather than three. The first category, consisting of a "fostering/collaborative" learning environment, included characteristics from the first two categories identified by the students. The second category, consisting of a "transmitting" learning environment, coincided with students' and teachers' perceptions in an obvious way.

Statistical analyses show that the students' perception of their learning environment conditioned how they perceived their expectations of academic success in this same environment. In fact, when the environment was considered "transmitting," the result was generally negative. Also, students who negatively evaluated a "transmitting" learning environment tended to positively perceive "fostering" and "collaborative" environments, which they felt were more effective in promoting learning.

Student retention and academic success of high-performing students

The researchers divided the sample of secondary school graduates into two groups: one group had performed poorly in mathematics and science and the other had achieved good results in these subjects. Of the high-performing students in mathematics and science, who were therefore capable of continuing in these fields, a certain number nevertheless chose to take another direction in their college studies. The researchers then looked at whether there was a correlation among these students' perceptions of the learning environment, their personal characteristics and their decision not to continue in mathematics and science.

TABLE 3

Three types of learning environment, as perceived by students

1.	**Fostering**	The teacher adopts an attitude that fosters feelings of confidence and competence. The student is encouraged to think for himself or herself, to manipulate ideas rather than memorize facts and formulas.
2.	**Collaborative**	Interaction among students is promoted and even systematically organized, both in class and through group work. Discussion is valued as an integral part of the learning process and as a means of maintaining interest.
3.	**Transmitting**	The teacher's role takes precedence in the learning process. The teacher focuses on the subject matter to be transmitted, which requires that students be receptive and rely more on memorization.

Methodology

Data on the correlation among perceptions, personal characteristics and student retention was based on a subset of 1 302 respondents (705 female students and 597 male students) from the sample of 2 479 questionnaire respondents. These students enrolled in an English CEGEP in the autumn of 2003: 923 in a science program and 379 in another program.

In order to quantify students' performance in mathematics and science, the researchers consolidated their results in mathematics and science courses, thus determining the "scientific potential" of the students in the sample. An analysis of variance then revealed that students enrolled in a college science program in 2003 had a higher scientific potential in secondary school than students enrolled in other programs.

Tests on the data pertaining to high-performing students made it possible to divide perceptions of the learning environment into two types in relative opposition, that is, "fostering" and "transmitting." A "fostering" environment was generally perceived as more effective in promoting learning, whereas a "transmitting" environment was viewed as less effective. It was thus observed that among the students who considered the learning environment in secondary school to be positive, 6% stopped studying science after Secondary IV, 18.7% after Secondary V, and 75.2% went on to enroll in a science program in CEGEP. On the contrary, 8.4% of students who perceived their learning environment as negative stopped studying science after Secondary IV, 26.3% after Secondary V, and only 65.3% continued with their science studies in CEGEP.

Notable differences between high-performing female and male students were observed during the data analysis of the subset. In terms of perception, 53.8% of the female students felt that their school environment promoted learning, whereas 46.2% of them thought the environment was not very conducive to learning; 59% of the male students thought their school environment promoted learning, whereas 41% felt it did not.

TABLE 4

Differences between the dropout and retention rates of high-performing students, according to perceptions of the learning environment

	STOPPED STUDYING SCIENCE AFTER SECONDARY IV	STOPPED STUDYING SCIENCE AFTER SECONDARY V	STUDENT RETENTION IN CEGEP
Fostering (positive)	6.0%	18.7%	75.2%
Transmitting (negative)	8.4%	26.3%	65.3%

Still with respect to high-performing students in secondary school science and mathematics, the dropout and student retention rates corresponded to the differences noted between female and male students in terms of how they perceived their learning environment: 8.7% of the female students stopped studying science after Secondary IV, 22.8% after Secondary V, and 68.5% continued in the sciences in CEGEP; 5.2% of the male students stopped studying science after Secondary IV, 21.1% after Secondary V, and 73.7% continued their science studies in CEGEP.

At least two findings stand out in the research results. Firstly, given that students who continued in science programs performed better academically than those who did not, it could be concluded that students stopped studying science because of poorer academic results, or a lower aptitude for science; however, this is not the case. In fact, more high-performing female students stopped studying science than high-performing male students. The research does not indicate why this is so, but it does specify that the reason is not poorer academic achievement.

Secondly, although fewer female students considered a "fostering" learning environment as positive, this type of environment nevertheless tended to promote student retention in the case of both male and female students.

RECOMMENDATIONS

By examining the correlation between students' perceptions of learning environment and student retention in science studies, the researchers raise some arguments in favour of educational reform at the college level.

Firstly, the researchers recommend that mathematics and science teachers be informed of the alarming rate at which secondary school and CEGEP students are deciding not to pursue their science and mathematics studies. Then, teachers should be made aware of the study's main finding that confirms the correlation between students perceiving a school environment to be "fostering" and subsequent academic success and student retention. Teachers could thus be encouraged to actively engage in professional development. Lastly, researchers recommend that the quality and frequency of science instruction be increased well before Secondary IV and V.

TABLE 5

Differences between high-performing female and male students in terms of their perceptions of the learning environment

	ENVIRONMENT PROMOTING LEARNING	ENVIRONMENT NOT PROMOTING LEARNING
Female students	53.8%	46.2%
Male students	59.0%	41.0%

TABLE 6

Differences between high-performing female and male science students in terms of student retention

	STOPPED STUDYING SCIENCE AFTER SECONDARY IV	STOPPED STUDYING SCIENCE AFTER SECONDARY V	STUDENT RETENTION IN CEGEP
Female students	8.7%	22.8%	68.5%
Male students	5.2%	21.1%	73.7%

A BROADER VIEW OF FACTORS RELATED TO STUDENT RETENTION AND ACADEMIC SUCCESS

As the two research teams are still processing the data they gathered, other findings may emerge. In the case of Professor Larose's team, recent data on student retention will make it possible to use the study's conclusions in a predictive manner. Rosenfield's team still has much data to process before it can answer specific questions, for example, does a calling for science that develops earlier on persist longer than one that emerges only in secondary school?

In conclusion, the Québec data confirms that efforts to improve student retention and academic success in science and technology programs should take into account a broader view of the factors at play so that adapted and effective initiatives may be undertaken in educational institutions as well as in the different environments in which students develop.

The document is available at the following address:
<www.mels.gouv.qc.ca>

DESIGN AND DEVELOPMENT
Gérald Baril
Centre de transfert pour la réussite éducative du Québec (CTREQ)

COORDINATION
Julie-Madeleine Roy
Service de la recherche
Direction de la recherche, des statistiques et des indicateurs

GRAPHIC DESIGN
Ose Design

ENGLISH VERSION
Direction de la production en langue anglaise
Secteur des services à la communauté anglophone
Ministère de l'Éducation, du Loisir et du Sport

Ministère de l'Éducation, du Loisir et du Sport, 2007 – 07-00177
ISBN 978-2-550-49757-8 (Printed version)
ISBN 978-2-550-49758-5 (PDF)
Legal deposit – Bibliothèque et Archives nationales du Québec, 2007

Éducation,
Loisir et Sport
Québec

20-2044-01A