A stitch in time: Preventing drop-out in Science Programs

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Abstract

In this study, the Science Access Program was evaluated using a non-equivalent groups pretest-posttest design. Two groups of students taking the same remedial courses in chemistry, mathematics and physics in Fall 1993 were selected from those enrolled in the Science Access Program and the Science Program, respectively.

The Science Access Program is designed for students whose high school success in science courses is marginal. They are likely to experience multiple failures in their first semester for the first time and are unlikely to be able to deal with it. Consequently, they risk becoming drop-outs. The Science Access Program integrates the course content of science courses with a study skills course. It sets conditions under which students learn problem solving skills and learning strategies while learning the content of the courses. The cooperation amongst the teachers provides mutual support, continuous monitoring of individual student progress, and leads to a stable learning environment. The success of the program is attributed to this integration and teacher's cooperation .

The pretest consisted of measures of prior academic performance: high school average grades, high school science performance and grades in physics test. The Regular Science students were better students than the Access students on these pretest measures.

The posttest consisted of measures of Cégep academic achievement: average final grade in science courses; academic success; and, perseverance in college . The Science Access Program students outperformed the Regular Science Program students on the final chemistry grade in A'93, on the final physics grade in H'94, and on the final mathematics grade in both semesters. The Science Access Program enhanced academic success in that more students in the Science Access Program passed the majority of their courses than did the students in the Regular Science Program. In addition, the Science Access Program increased the probability that students would persevere in their college studies.

Introduction

Academic success in college level science courses appears to be an exclusive privilege of students who have demonstrated excellence in high school science courses. Students whose high school science average[1] is below 72 % are frequently described as "at-risk" students. These students, if admitted into science programs and left on their own are prone to repeatedly fail their science courses. Terrill (1990) found that 50 % of students whose high school average is 64 -66 %, and 25% of students whose high school average is between 70 to 72 % are poor performers (achieve less than 64% in college science courses). Thus, many students with high school average grades between 65 % and 72 % are likely to experience serious difficulties.

Typically, there are two types of students who are "at risk": those who perform well in non-science disciplines; and those who are slightly below the admission criteria in all their courses. The first group of students has a good repertoire of the learning skills and strategies suitable to non-science courses. They may be lacking in science-specific skills and strategies. Without assistance, these students typically drop science and return to their previous interests. Providing these students with assistance, e.g., teaching them science-specific learning strategies, can improve their access and eventual success in Science Programs.

However, the admission of the second type of students directly into the Science Program poses a greater problem. If these students are admitted into Science Programs, many experience repeated failure, have a tendency to take a longer time to graduate (Levesque & Pageau, 1991) or may not graduate at all. If and when they do graduate, their grades are marginal. This limits their entry into university science programs. For example, McGill University's engineering programs require that the applicants have a GPA >75%. Other universities and programs have similar standards of admission. Consequently, these students are obliged to change their career goals upon graduation from Cégep.

[1] High school science average is an average of grades in: Grade 4 Mathematics, Grade 5 Mathematics, Physical Sciences 436, Physics 534 and Chemistry 534.

The costs associated with their struggle through the Science Program is prohibitive in both, human and economic terms.

Researchers in the Cégep system have designed and experimented with many programs e.g., Program de l'integration aux études collégial (PIC) (Larose & Roy, 1993) which address the needs of "at-risk" students. Many of these programs define students "at-risk" as students whose high school average is < 65 %. Two of these programs were specifically designed for science students - Developmental Science at Dawson College (Dawson College, 1992) and Explorations en science at Cégep St Laurent (Larose & Roy, 1993).

Vanier College in 1989 designed the Science Access Program to address the needs of both types of "at risk" students. Subsequently, Vanier either refuses science applicants with science grades below 72 % or offers them admission into the Science Access Program.

The science access program

A number of researchers in Quebec (a synthesis of their work can be found in Conseil des collèges, 1988; Lavoie, 1987; and Ducharme, 1990) and in the United States (Wallberg & Reynolds, 1991) have studied the factors affecting student academic success and attempted to build models of achievement. These factors can be grouped as 1) student characteristics (e.g., motivation, prerequisite knowledge, attributions for success, attitudes towards learning, etc.); 2) characteristics of the college environment (e.g., teachers' characteristics, teachers' beliefs, availability of student services such as counselling, academic advising etc.); and, 3) characteristics of the students' home environment (e.g., father's level of schooling, family income, etc.). Since colleges can only influence the first two groups of factors, only these factors are discussed below.

Terrill (1988) showed that the weighted high school average (MPS - moyenne ponderée au secondaire) is a reliable predictor of college performance. The report by the Conseil des Collèges (1988) suggested that factors, other than prior performance, might be involved in students' failure. Many such factors have subsequently been identified. For example, anticipation of failure, exam anxiety, beliefs about difficulty (Falardeau, Larose & Roy, 1988) , knowledge of learning strategies (Blouin, 1987), students' self-efficacy (Barbeau, 1994, 1995), control beliefs (Pintrich, Boyle & Marx, 1993), positive feelings towards learning (d'Apollonia & Glashan, 1992), attributions for success (Weiner, 1992), self-regulated learning (Zimmerman, 1990), mastery goals (Meece, Blumenfeld, & Hoyle, 1988) and social integration (Larose & Roy, 1992).

Larose and Roy (1991) showed that these motivational and affective factors are especially important predictors of future success for "at risk" students (comparable to the weighted high school average). Thus, the Science Access Program was designed to attempt to modify the students' academic competence, motivation, social adaptation, and goals by the following means:

Academic competence

- by focusing on the quality and quantity of prerequisite science background knowledge;
- by promoting the use of learning strategies;
- by encouraging the development of appropriate study habits.

Motivation

- by promoting self-regulated learning in science courses.

Social adaptation

- by using cooperative learning techniques to promote the formation of social networks;
- by acquainting students with college resources.

Ggoals

- by guiding students to set both short and long term academic goals;
- by guiding the examination and exploration of career plans.

Since, the college environment also affects student achievement, the Science Access Program also introduced institutional changes which promote changes in the student characteristics discussed above and therefore, promote academic success. The three teachers teaching the remedial science courses cooperated amongst themselves and with the teacher teaching the study skills course. They held weekly meetings prior to and during the implementation of the program. They maximized the effectiveness of the remedial courses by redesigned the curriculum and integrating the study skills course with the remedial courses. Thus, the study skills course included some topics which were common across all three remedial science courses, and other topics which differed across the three courses. Thus, students could learn both to transfer their knowledge across domains and to develop learning strategies specific to a domain. The teachers also coordinated course objectives, evaluation policies, and policies regarding regular homework. This coordination helped students develop good study habits and facilitated their time management. Additionally, it lead to a stable learning environment which was shown to be beneficial by Lasnier (1992).

The teacher cooperation facilitated monitoring individual students across their courses and encouraged prompt intervention to prevent failure. This cooperation extended to the sharing of successful teaching strategies and provided essential mutual support.

The Science Access Program encouraged cooperation between these teachers and professionals from the academic advising and counselling departments. Thus, these departments organized seminars on stress management, career planning and attribution retraining for the Science Access students.

A Science Centre was created to provide a location where students and teachers could work together. Bi-semester Science Access Lunches were organized in the Science Centre. These lunches along with a common, attractive physical space facilitated social adaptation and promoted regular work habits.

Thus, the Science Access Program offers "at risk" students a chance to improve their science performance and subsequently become successful science students. The goal of this study is to compare the academic success of students enroled in the Science Access Program to that of students enroled in the Regular Science Program and thus to evaluate the efficacy of Vanier's Science Access Program.

Methods

Participants

Forty seven students, with a high school science average below 72%, were enrolled in the Science Access Program in A'93. These students registered in a study skills course called Learning Science (360-902-85) and in three concentration courses in chemistry, mathematics and physics. Depending on their high school grades, they registered in either regular or remedial courses. The majority of students registered in at least two remedial courses. The twenty three students who were registered in three remedial courses (Chemistry 111, Mathematics 101 and Physics 111) were chosen as the treatment group. Twenty students, registered in the Regular Science Program and enrolled in the same three remedial courses as the Science Access students were selected as the control group.

The results of a study of prior academic achievement in both treatment group and control group indicate that the two groups were not equivalent. The Regular Science students had higher high school average grades than the Access students. In addition, distribution of science grades in high school science courses were different in the two groups. The distributions of science grades were skewed in opposite directions. It was positively skewed for the regular Science students, but negatively skewed for the access students.

Design and Measures

This study used a non-equivalent groups pretest-posttest design. The pretest consisted of three measures of student prior academic achievement: (a) high school average grade; (b) high school science performance measured ordinally with 1 denoting an average grade above 85 %, 2 an average grade between 80 % and 84 %, 3 an average grade between 75 % and 79 %, etc.; and (c) grade on the physics test administered to all incoming science students in May.

The posttest consisted of three measures of students' Cégep academic achievement: (a) the average final grades in chemistry, mathematics and physics; (b) academic success measured ordinally with 3 denoting success (a pass grade) in all three science courses, 2 denoting success in two science courses, 1 denoting success in one science course, and 0 denoting success in no science courses; and, (c) perseverance in college, measured by whether a student registered (in any program) in the following year (A'94).

Hypotheses

The Science Access Program was designed to improve students chances of success in their studies in the Science Program and/or to help them to select an alternative program of studies. The following hypotheses are proposed:

1. The Science Access students will have higher average final grades in all three science courses compared to the students in the Regular Science Program.
2. The Science Access students will have greater academic success than the students in the Regular Science Program.
3. The Science Access students will persevere in their college studies to a greater extent than the students in the Regular Science Program.

Results

The data were analyzed using both descriptive and inferential statistics. However, because, in this study, the sample sizes were small and the standard deviations were large, the statistical power of the tests (chi-square and t-test) was too low to be meaningful. Under such conditions, Cohen (1977) recommends using the effect size index, d. This index measures the magnitude of the treatment effect[1] with effect sizes of 0 .20 , 0.50, and

[1] d is calculated by using a formula $d = (m_e - m_c)/ SDp$, where SDp is the pooled standard deviation; m_e and m_c

0.80 indicating small, medium and large treatment effects respectively.

Table 1 Final grades in Science Courses. M_{CH}, M_M and M_P denote the means of final grades in chemistry, in mathematics and in physics. The standard deviations SD are shown in brackets.

A'93 - final grades			
	M_{CH} (SD)	M_M(SD)	M_P(SD)
Access N = 23	69(10)	69(14)	67(14)
Regular Science N = 20	57(22)	58(25)	65(19)
effect size	.75	.57	.1
H'94 - final grades			
	M_{CH}(SD)	M_M(SD)	M_P(SD)
Access N = 15	66(7)	56(18)	67(10)
Regular Science N = 16	65(14)	51(26)	46(25)
effect size	.1	.2	1.3

Cégep Academic Achievement

Students' Cégep academic achievement was measured by determining the students' final grades in their chemistry, mathematics and physics courses both in the semester they were enrolled in the Science Access Program (A'93) and in the subsequent semester (H'94) in which they were enrolled in the Regular Science Program. The results, illustrated in Table 1, indicate that Science Access students performed significantly better ($p < .05$) in their physics course in the second semester, than did the regular students. Moreover, the effect size indices demonstrate that in A'93, the Science Access Program had a medium to large effect in chemistry and mathematics and a small effect in physics. However, in H'94 the effect sizes were small in both mathematics and chemistry and large in physics. For example, in A'93, the Science Access Program improved the performance of the average student in chemistry from the 50th percentile to the 77th percentile. In H'94, the Science Access Program improved the performance of the average student in physics from the 50th percentile to the 90th percentile.

Academic Success

Academic success was also measured both while the students were in the Science Access Program (A'93) and in the following semester (H'94). Chi-square tests indicated that there was a significant effect ($p < .05$) of the Science Access Program on the frequency distribution of academic success in both A'93 and H'94. Figure 1 shows the number of students passing 3, 2, 1, and 0 science courses in A'93 and in H'94. While, the frequency distribution of academic success for students in the Regular Science program is almost flat, that for students in the Science Access Program shows a peak at 3. The Science Access Program decreased the students' chances of failing all their courses. In A'93, 30 % of the Regular Science students failed all their courses as opposed to only 4 % of the Science Access students. In H'94, 25% of the Regular Science students failed all their science courses as opposed to 0% of the Science Access students. Moreover, in A'93, 65 % of the Science Access students passed all science courses while only 50 % of the Regular Science students did so.

Figure 1. Academic success. Note that N = 20 for the regular Science students and N = 23 for the Science Access students.

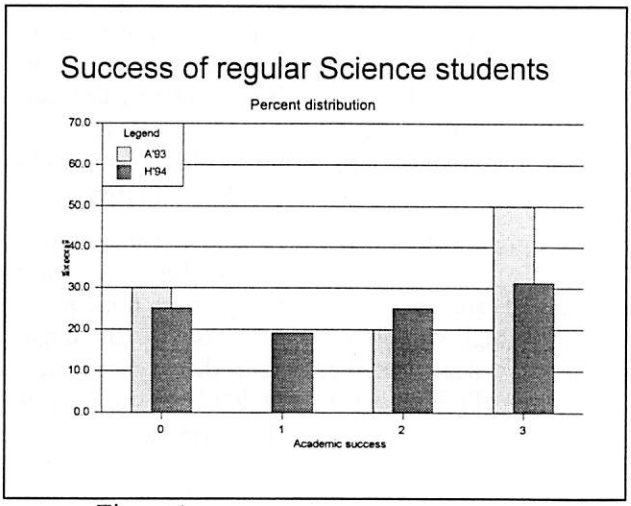

Figure 1

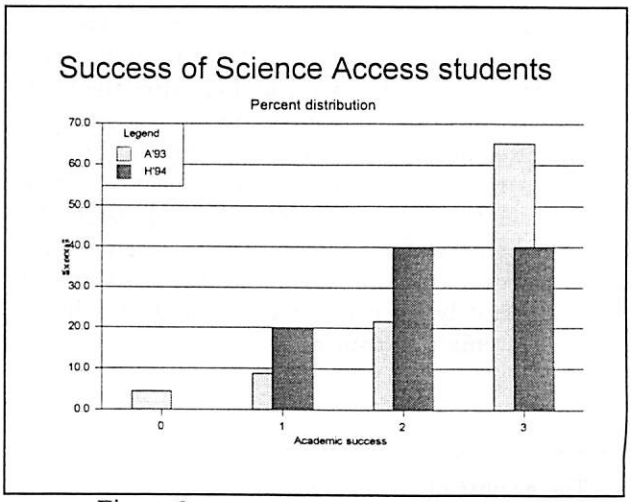

Figure 2

are the means for Access and regular Science groups, respectively.

Perseverance in college

Perseverance in college was measured one year after the treatment. In A'94. 100 % of the Science Access students were still registered in the college but only 75 % of the Regular Science students. The Science Access Program enhanced the probability of the average student remaining in college from 0.5 to 0.86 (the effect size index is 1.1)[1]

Discussion

One of the limitations of this study is the small sample sizes of both the treatment and the control group. This severely limits the interpretation of statistical results. A second limitation is that the final grades used in this study may not be comparable because the grading practices of different teachers vary and therefore the same grade may represent different student performance.

A third limitation is that students were not randomly assigned to the treatment group, and therefore, alternative explanations for the results cannot be ruled out. Finally, students' academic performance is a result of many factors such as, motivation, beliefs, family climate, etc.; no data on these factors were collected.

The comparison between high school average grades for the Science Access students and the Regular Science students indicates that the two groups were not equivalent. These high school grades indicated that the Regular Science students were better than the Science Access students. Terrill andDucharme (1993) have shown that even a small difference in high school averages results in differences in future performance. Consequently, the Regular Science students' probability of success in college courses was higher than the Science Access students' probability of success.

The Science Access students performed better in mathematics in both semester with a medium effect during the treatment and a small effect after the treatment. In chemistry, the Science Access students performed better during the treatment; while, in physics, they performed better after the treatment. In both chemistry and physics, the effect size was large. Although the effects of the Science Access Program were neither uniform across the disciplines nor cross time, it had a moderately positive effect on student achievement in concentration courses.

The academic success rate in science courses indicated that in both semesters, the Access students were more likely to pass their concentration courses. In A' 93, 65 % of access students passed all concentration courses while only 50 % of regular students passed all their concentration courses. A comparison of the frequency distribution of students' academic success shows that the Science Access Program significantly improved the academic success rate of the students enrolled in the program.

The perseverance of the Access students was higher than that of the Regular Science students. The size of the effect is large and thus, the Science Access Program considerably enhanced the probability of students remaining in the college. The treatment benefits students by encouraging the critical evaluation of career plans, by emphasizing the importance of setting academic goals and by encouraging seeking academic advice when needed. Several Science Access students changed program and succeeded in the new program. In contrast, the Regular Science students rarely changed programs. They continued to perform poorly in sciences or disappeared from the college. By encouraging students to select the area of study which suits their interests and abilities, the Science Access Program promotes persistence. Thus, we believe that persistence is the best indicator of the success of the program.

The analysis shows that the Science Access Program had a positive effect on all three measures of success. The results of this study are similar to those of other programs in the Cégep system (Larose & Roy, 1993). Two other programs for science Cégep students also report similar positive effects of their intervention on both perseverance and achievement (Dawson College, 1992; Larose & Roy, 1993). Unfortunately, neither of these studies compared the achievement of an experimental group to a control group.

Statistically speaking, the most important effect of the program is on academic success. By avoiding failures, Science Access students benefitted from the program. Pedagogically and economically speaking, the most important effect of the program is on perseverance, especially in view of the fact that the students were able to find their place in Cégep and in their field of study. However, for continuing success in sciences, Science Access students must meet the demands of university admission. Unfortunately, the means in all three concentration courses indicate that only a few Access students, if any, met these standards. It is a small consolation that the Regular students did not perform any better. An optimistic view holds that the few Access students who met the standards would not have had a chance without the Science Access Program.

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[1] The number of students declined in the H'94 because some Regular Science students withdrew from the college or some students in both groups transferred into another program.

In conclusion, the Science Access Program was shown to benefit students in the short term. A longitudinal study of the cohort '93 is necessary to evaluate the long term effects of the program on the rate of graduation. An additional study, which measures motivational and affective factors, which includes common achievement measures, and which includes random assignment of students into programs is necessary to exclude alternative explanations.

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La mesure de la réussite scolaire

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Résumé

Plusieurs chercheurs/es du réseau collégial doivent, dans le cadre de leur recherche, mesurer la réussite scolaire et la réussite éducative. On observe qu'il y a une grande diversité dans la conception et dans la mesure de la réussite scolaire. Le présent texte traitera des sujets suivants : propositions pour la mesure de la réussite éducative, propositions pour la mesure de la réussite scolaire, différentes approches et différentes mesures, les problèmes reliés à certaines mesures, un exemple d'opérationnalisation de certaines mesures et finalement quelques recommandations. Le texte soulèvera aussi un certain nombre de problèmes non résolus.

1. Problématique

La mesure de la *réussite scolaire* se situe dans le cadre générale de la *réussite éducative*. Le concept de réussite éducative n'est pas encore défini de façon précise et exhaustive. Lors d'un récent séminaire de l'ARC, Lasnier (1995), Larose (1995) et Terrill (1995) ont présenté quelques suggestions pouvant nous éclairer sur l'opérationnalisation de la mesure de la réussite éducative.

Larose (1995), en s'inspirant de la notion de compétence sociale de Cavell (1990), a présenté des indicateurs de la compétence scolaire au collégial. Celle-ci serait composée de six variables : l'ajustement au collégial, l'adaptation au collégial, les habiletés scolaires, l'engagement personnel au collège, l'orientation scolaire et la réussite scolaire. Lasnier (1992; 1995) a mentionné des variables telles que la réussite scolaire, l'adaptation au collégial, les liens entre les étudiants, l'expression de ses besoins, l'entraide, le sentiment d'appartenance à son collège, le sentiment de compétence cognitive et la socialisation.

Le présent texte s'intéresse de façon spécifique à la mesure de la réussite scolaire, considérée comme une des composantes de la réussite éducative. Il a pour but principal l'élaboration de principes de base permettant d'orienter l'évolution de la mesure de la réussite scolaire et d'aider à cheminer vers une mesure standard afin de pouvoir comparer les recherches entre elles et ainsi cumuler l'information de façon plus structurée.

Jusqu'à ce jour, l'analyse de la mesure de la réussite scolaire révèle un certain nombre de problèmes. D'abord, on constate qu'il y a de nombreuses recherches dont une des variables dépendantes importantes est la réussite scolaire. Dans un deuxième temps, on observe qu'il y a une grande variabilité dans les façons de mesurer la réussite scolaire. À titre d'exemples, on note la proportion de cours réussis, la moyenne collégiale, la proportion d'échecs. Parmi cette panoplie de mesures, certaines sont plus valables que d'autres. De plus, certains problèmes de mesure ne sont pas résolus; par exemples: la pondération selon la nature des cours, les notes inférieures à 30 qui sont ramenées à 30 pour calculer la moyenne, l'attribution d'une note de 55 pour un abandon (les abandons n'existent plus au collégial, mais cette pratique a été souvent utilisée dans le passé). Les traitements statistiques varient aussi considérablement dans l'ensemble des recherches relatives à la réussite scolaire. Tous ces problèmes rendent la synthèse des résultats de recherche très compliquée, même quelquefois impossible. La principale conséquence d'une telle situation, résulte dans une perte d'informations et dans l'impossibilité de cumuler de façon sommative une série de résultats sur un même sujet. Nous sommes souvent obligés d'analyser les résultats de recherche un à un, sans dénominateur commun. En somme, il est difficile d'identifier clairement des indicateurs de réussite scolaire lorsque celle-ci est rarement mesurée de la même façon. Il serait donc souhaitable de proposer une mesure standard, sans pour autant, limiter la créativité des chercheurs. Ainsi, on pourrait utiliser plus d'une mesure de la réussite scolaire dans une même recherche (une mesure standard commune à tous et d'autres mesures propres au contexte spécifique de chaque recherche).

2. Différentes approches

La lecture de rapports de recherche effectuée dans le réseau collégial et de certains écrits (Morissette, 1993) sur la mesure montrent que la réussite scolaire a été mesurée avec plusieurs approches différentes. Voici une liste de différentes approches recensées:

- différence entre le *début* et la *fin* d'une activité;