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**Department of Mathematics and Statistics
Memorial University of Newfoundland**

Self Study Document

DRAFT

1. STRATEGIC OBJECTIVES, HISTORY AND GOALS

This section begins by reviewing the strategic objectives of the university and how they are translated into objectives for the Department of Mathematics and Statistics. This is followed by brief summary of departmental history from the early 1980s until 1998. The period from 1998 until the present is then discussed in greater detail in a manner to enable the formation of an opinion as to how well the Department of Mathematics and Statistics and the university are jointly meeting the objectives set out below.

1.1. Strategic Objectives

1.1.1. University Objectives

The university has recently gone through the exercise of setting out a strategic framework for the university. The Framework document, which has been approved by Senate, is included as Appendix 1 as document A1.1¹ and it is from this document that strategic objectives of most relevance to the department's mission have been extracted. The Framework document reflects the content of the *Statement of University Principles and Goals* which is included as A1.2. What follows are direct quotes from the Framework document:

Memorial will continue to provide strong academic support to undergraduate students and to support extensive involvement of regular faculty in undergraduate classrooms and laboratories, but in response to the needs of a changing economy it will also expand research and graduate teaching as high priorities. The demands of a knowledge-based economy and society make scholarly research more important than ever, ... (p. 1)

The following are taken from section II of the framework document which contains principles and goals approved by Senate in May 1999. There are two guiding understandings:

that Memorial University's current size and basic character as a medium-sized comprehensive university offering a broad range of undergraduate and graduate programs in basic Arts and Science disciplines and in selected professional areas are essentially right, and that provision of undergraduate teaching of the highest quality is an essential and continuing requirement of our mission. (p. 2)

¹Each section of this report has an appendix that includes all documents mentioned in the section. Documents are included only once, in the section of first mention, and are numbered consecutively, by section number as in A1.1, A1.2, etc.

Because Memorial exists in the first instance to educate the people of this province, we undertake to provide our students with teaching of the highest possible standard, ... (p. 3)

In respect to research, the following appears in a section articulating goals:

Regardless of discipline, the advancement and application of knowledge through basic and applied research is an essential part of our mission. (p. 5)

In the same section, improving undergraduate recruitment and retention is identified as a goal.

In a section in which raising graduate enrollments, implementing a policy of faculty renewal and increasing collaboration and coordination as goals are identified, the following direction is given to units:

... makes it incumbent on individual units to pursue their objectives in a manner which contributes to the achievement of the University's goals. (p. 5)

The following are articulated as important principles:

Equitable resource allocation is an important means of achieving the University's goals, (p. 4)

and,

Important decisions must be taken collegially. (p. 4)

1.1.2. Departmental Objectives

As a Department of Mathematics and Statistics in the sole university in Newfoundland, we interpret the above as implying that we have broad educational responsibilities that include:

- provision of excellent undergraduate instruction in pure and applied mathematics, and statistics;
- provision of excellent graduate programs in pure and applied mathematics and statistics;
- provision of excellent service instruction in mathematics and statistics to students in the large number of university programs that have a mathematics and/or statistics requirement;
- a particular responsibility to provide excellent mathematical instruction to future teachers of mathematics at all levels.

In particular, the department should take all possible steps to enhance the recruitment and retention of students that are consistent with maintaining the standard of a first class university degree.

In respect to scholarship we have a responsibility

- to produce new knowledge in pure and applied mathematics and in statistics;
- where possible, to transfer knowledge and expertise to the industrial sector and the community;
- to generally act as a community resource at all levels in respect to mathematics and statistics, in particular by providing advice to government on mathematics education issues.

Of particular importance to achieving these objectives over the long term, is the hiring practices of the department. Care must be taken to ensure that potential faculty are both skilled at research and at teaching.

The overall strategic objective of the department is to meet these responsibilities in a cost-effective manner.

1.1.3. University Responsibilities

It must be recognized that the Department of Mathematics and Statistics cannot meet these responsibilities alone. To do so requires the support and active cooperation of the remainder of the university, most importantly by supplying the resources required to achieve success, and also by implementing academic proposals designed to enable the Department of Mathematics and Statistics to better meet the obligations set out above. Therefore, the university has a responsibility

- either to ensure that the Department of Mathematics and Statistics has sufficient resources to meet its obligations,
- or to redefine the obligations to match the resources the university is prepared to supply.

Similarly, in respect to academic proposals, the university has an obligation either to cooperate in respect to the approval of proposals, or to eliminate the parameters that make the proposals necessary.

1.2. History Prior to 1997

The last external review of the department occurred around the time we moved to our current location in the Henrietta Harvey Building in the early 1980s, in other words, almost 20 years ago. During the period since the review to 1997, a variety of programs were introduced, e.g., B.Sc. in applied mathematics, MAS and PhD in statistics, etc. These are documented elsewhere.

In terms of graduates, the department was graduating between 30 and 50 majors per year in the Faculties of Arts and Science. This number varied from four to six per cent of the total number of graduates from the Faculties of Arts, Engineering and Science.

In terms of research during this period, there were two individuals who were promoted to the rank of university research professor. As well, approximately 15 faculty were continuously supported by

NSERC for periods exceeding 20 years.

The remainder of this section will focus on events related to entry-level and service teaching. This teaching comprised more than 7,000 registrations on an annual basis, in other words, considerably more than half the total teaching of the department².

In the early 1980s, our entry-level classes were taught in sections of <40 with faculty resources to match³. Using a combination of regular full-time faculty and sessionals, more than 250 sections of undergraduate mathematics and statistics were offered on an annual basis.

By the late 1980s, coupled to rising enrollments (from 8,000 registrations annually to more than 10,000), class size in entry-level courses in mathematics rose from the mid 30s to 70, with no labs or tutorials. In statistics they were 120. The total number of sections offered on an annual basis dropped to 225. The effect on educational quality was noticed both within and without Memorial and resulted in the government striking a Task Force on Mathematics and Science Education. In his report to government⁴. Dr. R. Crocker attributes “deterioration in teaching conditions in first-year mathematics courses at Memorial” as a major causative factor for the increase in failure rates that had led to the creation of the Task Force. The primary causative factor identified was “low expectations in high school mathematics, and particularly the selection by most students of academic, rather than advanced, mathematics,” (p. 16).

Slightly before the Task Force study, the department created a learning centre to deal with entering students needing remediation. This centre runs a program developed by R. Zimmer. During the period from 1989-1998, all its programs were voluntary. The centre was moved out of the department in the early 1990s to operate under the auspices of the School of Continuing Studies. In 1997, it was moved under the dean of science where it operates today as the Mathematics Learning Centre (MLC). It was reviewed last May and the report is A1.5.

In the period from 1990 to 1997 section sizes continued to rise, reaching 100 in the fall offering of entry-level calculus. The number of sections offered (exclusive of the MLC) fell to about 175 and faculty numbers were reduced — by the spring of 1997, the number of regular full-time faculty had fallen to 37, supported by three contractuales and numerous sessionals.

In the 1995, at the request of the then dean, Alan Law, the department prepared a *Five Year Plan* included as A1.6. To the degree that resources have been available, the department has implemented the plan, e.g., computing facilities have been refurbished, more computing support is available, the

²*Academic Unit Profile 1998-99*, p. 53. See A1.3.

³A faculty full-time complement of 50 (including 11 statisticians) is the number showing in *Fact Books* in the early 1990s.

⁴*Towards an Achieving Society Summary Report*, Task Force on Mathematics and Science Education, May 1989, p.16. The Summary Report is A1.4.

help centre has a full-time manager for eight months per year. However, much remains undone as will be evident below.

The period from 1990-97 culminated with the issuance of the report of the Senate Ad-Hoc Committee on First-Year Math Courses, which is included as A1.7. Senate struck this committee to investigate failure rates in entry-level mathematics courses after the Senate Committee on Undergraduate Studies rejected the department's grades in M1001 (integral calculus) the previous fall. Its report condemned many practices that the department had adopted in the name of efficiency to respond to declining budgets. As well, it wondered why recommendations in the Crocker Report had never been acted on (see page 8). Significantly, it also recommended placement, a practice the department had voted to begin the previous fall.

1.2.1. History Fall 1997 to Present

What follows is a very brief summary of the key activities of the department during the period from Fall 1997 to the present. Details will be found in other sections.

Undergraduate Program. The department accomplished the following:

- submitted a proposal on placement using the SAT Level IC and IIC Subject Area Tests in Mathematics to Senate in December of 1997 as required by the Senate Report (see A1.8);
- submitted an interim response to the Senate Ad Hoc Report to Senate in March 1998 (see A1.9);
- implemented compulsory placement using the Math Skills Inventory in the fall semester of 1998;
- developed a detailed response⁵ to the Senate Report submitted to Senate in fall 1998;
- initiated a review of all undergraduate programs in winter 1999;
- implemented many of the recommendations detailed in the Response Report.

On an annual basis the department dealt with approximately 10,000 lecture registrations, taught approximately 175 lecture sections and produced from 25-70 graduates from its programs.

Graduate Program. In respect to graduate program the department took the following steps:

- began a major push to increase graduate enrollment - it is now 19;
- negotiated increased baseline support from the dean of graduate studies;
- instituted a policy of using qualified students as per-course instructors in undergraduate courses with section sizes bounded at 40 in entry-level mathematics and 60 in entry-level statistics courses having a laboratory period;
- instituted a teaching support program for graduate students to ensure quality instruction is maintained;

⁵ *Ad-Hoc Senate Response Committee on First-Year Mathematics Final Report* included as A1.10.

- undertook a general review of practices to increase effectiveness and efficiency of the program.

Research. Throughout its history, the Department of Mathematics and Statistics has had a core of faculty committed to excellence in curiosity driven research. Many of these faculty have received continuous funding from NSERC over periods of more than 20 years and have, over time, achieved outstanding reputations as scientists.

The department achieved the following of particular note:

- increased its NSERC support from \$183,031 to \$266,536;
- all new faculty obtained NSERC support;
- had four faculty receive major awards for their scholarly work;
- had a substantial increase in the number of visitors to the department engaging in collaborative work;
- began cooperative work with the Department of Fisheries and Oceans through the Statistical Consulting Centre and the Marine Institute;
- began cooperative work with Guigné International;
- hosted the Canadian Mathematical Society meeting in the summer of 1999;
- hosted the Atlantic Provinces Council on the Sciences (APICS) meeting in the fall of 1999;
- was awarded a CFI grant for new faculty that enabled the department to acquire a 50 node Beowulf cluster;
- brought the directorship of the Atlantic Association for Research in the Mathematical Sciences to Memorial.

The department graduated two students with masters degrees and six with PhDs during this period.

Administration. In respect to administrative organization, the department

- created the position of undergraduate officer whose primary duty was to provide advice to students and other university units in respect to the department's programs;
- put in place the position of graduate officer;
- negotiated a budget increase to cover 1.5 additional PYs of computer support;
- negotiated an agreement with the Department of Computer Science for support of the department's computer systems.

Hiring. The department accomplished the following hirings:

- ten faculty into tenure track positions;
- one undergraduate officer;
- three individuals in computer support positions, bringing total support levels to 2.5 Pys.

The filling of 10 tenure-track positions gives the appearance that the department is thriving. The facts are that the number of regular full-time faculty as shown in the *Academic Unit Profile 1998-1999* was: 1995, 40; 1996, 40; 1997, 37; 1998, 34; 1999, 37. The number of regular full-time faculty available to undertake teaching duties in the department as of this moment is 37.5. One of these will most likely resign in August, another will complete her teaching duties in December and undertake two years of unpaid leave prior to retirement in August 2003, and a third has to retire in August 2001, so that the number available to undertake teaching next fall will be 34.5⁶. Quite clearly the department is losing ground fast.

Although a hiring plan has been submitted to the dean to provide for the future, it has not been accepted and indeed where the hiring of regular full-time faculty is permitted in the Faculty of Science, it is not in the Department of Mathematics and Statistics.

It is a fair description that the operation of the department in recent years could best be described as being *cobbled together*, a phrase used by our current dean. This mode of operation will soon end because

it is a simple fact that almost 50 per cent of our current faculty could retire within the next five years and many are likely to do so (see Sec. 2).

1.3. Goals

That the Department of Mathematics and Statistics will shortly cease to function in its present form due to retirements and/or resignations is a simple fact. Thus it is essential that the university have in place a plan that will permit the department to evolve to a new state.

We have identified a model that we believe will meet the needs of the future Memorial University. This model is consistent with a student body of approximately today's size and assumes the Department of Mathematics and Statistics would offer approximately 180 graduate and undergraduate lecture sections with regular full-time faculty. The two principles on which the model is based, namely, increasing instructional quality and becoming recognized as a world class research department, were arrived at through collegial discussion and have near unanimous support within the department⁷.

The approach is based on studying the models that have been successful elsewhere (see *Towards Excellence: Leading a Doctoral Mathematics Department in the 21st Century*, Chapters 8 and 11)

⁶A complete list of faculty including summary data is included as A1.11. Note that Don Bass is jointly appointed with Engineering, S. May is seconded as director of the MLC, and R. Rees has a special contract involving only research based on health.

⁷A1.12 contains a memo to the department reflecting the conclusions from discussion of this issue at department meeting. The plan presented is based on the two principles and the university goals. Should the university agree to the general elements in the plan, substantial additional collegial discussion leading to refinement of the plan would need to take place.

and is predicated on delivering outstanding undergraduate education in mathematics and statistics by recognizing that to do so requires an investment of resources in instruction at entry levels. This translates directly into reversing some of the instructional trends that began in the early 1980s.

Reversing these trends requires a substantial investment in faculty. We propose a permanent complement of approximately 50 tenure-track faculty. These would be assisted by an additional complement of three faculty hired as postdoctoral term appointments on three-year non-renewable contracts (see *Towards Excellence: Leading a Doctoral Mathematics Department in the 21st Century*, pp. 85 and 88). Additional teaching would be provided by a complement of 60 graduate students. This teaching complement could provide the equivalent of 275 units of lecture section teaching on an annual basis, and would cover all the instruction requirements of the Department of Mathematics and Statistics, including graduate and undergraduate lecture sections, labs, and thesis supervision. Any surplus would be used in the first instance to enhance instructional quality and in the second to enhance research productivity. There would be no necessity to hire sessional instruction from outside this complement. The cost to the university on a per-student basis is no more than the university provides to other units in which high quality undergraduate instruction has been identified as a priority (see *Academic Unit Profile 1997-1998* report).

The key to the success of this plan is the continuing ability of the Department of Mathematics and Statistics to hire postdoctoral term appointments and attract graduate students. To achieve this, Memorial's Department of Mathematics and Statistics must achieve a world-class reputation. To do this, the department proposes that the university enter into long-term relationships with four outstanding researchers: three in pure and applied mathematics, and one in statistics. These individuals would agree to come to Memorial on an annual, or semi-annual, basis to act as director of a month-long research workshop. These workshops would attract researchers from around the world and provide a stimulating environment that would attract young mathematicians and statisticians to Memorial as a place to develop a career.

With the advent of the Canada Research Chairs program it became evident that the award of a chair to the department could substantially raise our ability of the department to achieve these goals. To this end, the department submitted to the university a proposal that it be awarded at least one chair. This would recognize the central nature of the discipline and its essential contribution to the university. That proposal is included as A1.13. The university's *CRC/CFI Strategic Research Plan* is included as A1.14⁸.

In summary, the goals of becoming world class at research and increasing the quality of our undergraduate teaching are inextricably linked. Because of the mixture of teaching by faculty and graduate students, the plan is practical. The details of what we need to implement our proposals are:

⁸A Chair in simulation was announced for the Faculty of Science for which the department has a representative on the search committee. However, the reader can judge the degree to which the university ascribes importance to mathematics and statistics in its research priorities by reading the *CRC/CFI Strategic Research Plan*. Also included as A1.15 is the submission for the Faculty of Science for chairs in *Other Areas of Excellence* and a memo from the Dean of Science that prioritizes chair proposals.

- a permanent faculty complement of 50 with a suggested minimum complement⁹ in pure mathematics of 15, in applied mathematics of 15, and in statistics of 13;
- three permanent positions, filled by Postdoctoral Term Appointees hired on three-year non-renewable contracts;
- a graduate program with approximately 60 graduate students;
- the award of a Canada Research Chair around which to further develop research excellence in the department;
- an active summer workshop program directed by internationally recognized mathematicians and statisticians.

As the results of this investment are realized, the reductions in undergraduate instructional quality that led to the Crocker and Senate reports will be reversed, and the following benefits to the department's undergraduate program will accrue:

- classes would be taught by people with a vested interest in the long-term success/well-being of the department;
- all classes will be taught by individuals with a PhD, or, who are in Memorial's graduate program;
- all laboratories would be taught by the course instructor;
- all instruction by non-permanent staff would be supported and monitored through the system currently under development to support graduate student instructors;
- dependence on sessionals whose only relationship to the department is as a sessional instructor would be reduced, and eventually eliminated;
- a generally higher quality of instruction in service courses, than has been the case in the past, would obtain.

2. FACULTY

2.1. Demographics

Document A1.8 contains a complete list of all permanent faculty together with their birth date, date of appointment, date of all promotions, record of all degrees earned. The *Curriculum Vitae*s of all faculty are compiled as A2.1. This information is supplemented by a faculty complement record extending back to 1988 that documents the decline in faculty numbers (A2.2).

Most pressing is the age-related information contained in the table below that specifies the number of faculty by area now, next year, and in five years time.

⁹This distribution was approved at a Department Meeting.

Table 2.1

Area	2000	2001	2005
Pure Mathematics			
Algebra	4	4	4
Analysis	5	4	1
Combinatorics	2	2	2
Geometry	1	1	0
Number Theory	1	1	0
Math Education	1	1	0
Topology	2	2	0
Classroom Teacher	7	6	2-5
Applied Mathematics			
Classical AM	3	3	2
DEs/Dynamical Systems	3	3	3
Numerical Analysis	2	1	1
Simulation	1	1	0
Statistics Group			
Statistics	5	5	4-5
Probability	1	1	1
Total	38	35	21-25

It is clear that without a program of faculty replacement, the department will be substantially changed for the worse in the coming five years. It will be unable to maintain its present undergraduate and graduate offerings in any area. It will have no presence in analysis, geometry, number theory, mathematics education and topology, all of which are essential to a mathematics department. The situation in statistics is already past critical. There were 11 statisticians in 1989 immediately prior to the introduction of the PhD program in that area.

Although the department has submitted a hiring plan covering the next three years to address this situation (plan and covering memo included in A2.3), no positive response has been received. According to information supplied by the dean, five bridging positions have been put forward from the Faculty of Science in the current year. None were in the Department of Mathematics and Statistics (see A2.4). Also included in Appendix 2 is a compilation of permanent positions in mathematics and statistics at universities in North America taken from the AMS Web site (A2.5). A2.5 shows that the number available university of positions has increased dramatically, and this is a trend that is expected to continue as large numbers of university faculty retire. What this means is that lack of an effective bridging program will be extremely detrimental to many of the goals set out in this proposal, due to an inability to hire in a timely way.

2.2. Research Strengths and Weaknesses

The Department of Mathematics and Statistics has hired 10 tenure-track faculty in the past three years, including an internationally known senior algebraist from Moscow State, a fluid dynamicist who was awarded the Petro-Canada Young Innovators Award, an algebraist, two combinatorists, two applied mathematicians, and three statisticians. All are NSERC funded and, together with an existing complement of faculty committed to research, have created what can accurately be described as the major research department in the mathematical sciences in Atlantic Canada and a strong player on the international scene.

In terms of areas in pure mathematics, the strongest group is algebra which includes Bahturin, Goodaire, Parmenter and Zhou. Topology (Booth and Heath) was a previously identified area of strength, but it has suffered major losses in the past 10 years. All but one of those listed are in their 50s. In addition, there are two combinatorists (Pike and Shalaby) who are regular faculty, plus a third (Rees) who is on a part-time research only contract and who is not included in the faculty counts above.

Applied mathematics is in somewhat better shape, thanks to recent hiring. The group contains two outstanding senior members (Brunner and Summers) both of whom are University Research Professors, and three recent hires (Kocabiyik, Zou and Zhao). In addition, Charron has a contractual relationship with industry, although his resignation is expected in August 2001.

Statistics has two excellent senior researchers (Lee and Sutradhar) doing curiosity driven research. The department also hired three statisticians in 1998 (Oyet, Peng, and Sneddon). There is one probabalist, Wang.

The weaknesses are apparent from the discussion above, and under the extant regime, of no hiring in Mathematics and Statistics, will only get worse.

2.3. Teaching Strengths and Weaknesses

In the late 1960s, Memorial believed it had a problem in respect to the transition from Grade 11, the then terminal point in the Newfoundland secondary school system, to university. To deal with the problem MUN hired a group of individuals whose job was to provide instruction in the transition year. This group, most of whom were hired from the Newfoundland high schools, is identified as *Classroom Teachers* in Table 2.1. All teach five courses per year and their scholarly contribution is in the area of teaching.

The classroom teachers and many others, are dedicated teachers with substantial interest in innovation. However, the ability of the department to invest in innovation is limited for reasons discussed below.

The most fundamental weakness is a lack of resources with which to do the job. As shown in the *Academic Unit Profile 1998-1999* data, on an annual basis the department typically offers 190 undergraduate sections, some with labs. Of these, about 25 are offered by the MLC, so that the department is responsible for around 165 undergraduate lecture sections on an annual basis. At the

point the department has a fully developed program of graduate studies, we would expect to offer 20 lecture sections at the graduate level—at this moment the number is around 12-13. At best, the department will have 142 units of teaching available, assuming all full-time faculty teach four courses as specified in the *Collective Agreement*. When labs and graduate courses are included, the number of teaching units required rises to over 200, as shown in a budget memo to the dean dated 15 February 2000 included as A2.6. A revised memo dated 25 February 2000 showing a reduced number of teaching tasks was submitted at the request of the dean (see A2.7), but the number of sections proposed proved inadequate to meet demand, and the department was unable to operate within the budget targets set by the dean. What seems clear is that there is a fundamental mismatch between the demands placed on the Department of Mathematics and Statistics in respect to instruction by the rest of the university, and the ability of the department to meet those demands with the resources provided by the dean of science. Within five years, assuming no replacements, the number of available teaching units will fall to >100 , so that the problem will only get worse.

2.4. Contributions to the Profession

Department members are active contributors to their professions as can be seen from inspection of the *Beyond the University* section of recent departmental *Annual Reports* (see A2.8). Such inspection will reveal memberships on numerous Canadian Mathematical Society (CMS) committees, service on editorial boards, and so forth. That such commitment extends to the institution is shown by the hosting of two major conferences in the past year, namely, the CMS Summer Meeting in June 1999 and the Atlantic Provinces Council on the Sciences (APICS) fall mathematics meeting in October 1999, both of which received substantial financial support from the university¹⁰.

2.5. Potential and Morale

Given access to a fair share of university resources, the department could achieve its two identified objectives of, substantially increasing the quality of undergraduate instruction and, becoming recognized as a world-class research department. Thus, the potential is great.

However, the current state of our morale is not good. We are continually asked to be excellent, but as the facts show, never given anything like the required resources to do the job (see A2.6-2.7 which contains memos on resources and the *Academic Unit Profile 1998-1999* data in A1.2)¹¹

¹⁰Substantial support was received due to commitments made by W. Davidson, acting dean of science. Although the current dean of science did provide \$2,500 to support a workshop in May 2001, he was unwilling to provide any support for a request that MUN serve as the International Mathematical Olympiad (IMO) training site in 2002. Fortunately, another source was found (see A2.9).

¹¹In comparison to other units in, or out, of the Faculty of Science, the data in the *Academic Unit Profile 1998-1999* document show the department to be close to the bottom in respect to all measures that relate access to resources to job requirements, for example, expenditure per student registration.

2.6. Junior Faculty

Within the past two years, the department has hired six faculty that are within three years of completing their PhDs.

Career mentoring is performed in two ways. First, annual evaluations occur under Article 10 of the *Collective Agreement*. As well, current practice is that the head meets with all non-tenured faculty to discuss their situation. In such meetings, it is expected that the faculty member will present a research plan for the coming year(s), as well as other steps the individual has taken to ensure tenure, e.g., determining what teaching evaluations have occurred or will occur. The outcome of the meeting is a written submission from the faculty member and a written response from the head (samples are available on request).

2.7. Future

In the statement on goals, the department has articulated a view of its place in the future that is consistent with University and Provincial objectives. The work required to achieve these goals would be undertaken with enthusiasm. However, the attainment of these goals requires a partnership with the university. Such a partnership would provide for renewal and a vibrant future for the department within the university.

Lacking such a partnership, the future for the Department of Mathematics and Statistics is bleak¹².

¹²A2.9 contains a draft of Faculty of Science Priorities and Planning date 20 March 1998. The reader can assess the degree of partnership available within the Faculty of Science.

3. SCHOLARLY PRODUCTIVITY

The department's *Annual Report 1998-99* is included as A2.7. It concluded with seven pages listing items published, or submitted, with more than 100 items listed. A further five pages lists external lectures.

Approximately half the members of the department contribute to this list. If contributors from the past five years were included, the number would rise to, perhaps, 70 per cent.

The total number of publications and faculty are not significantly different than the pattern of five years ago. Specifically, the bulk of the scholarly activity, in terms of publishable mathematics and statistics, is carried by about half the department. This fact, that the bulk of the scholarship load is carried by so few, reflects the hiring practices of thirty years ago when the department, and the university, did not place the same emphasis on research. As well, the department is aging, and individual priorities change over time.

In addition to journal papers, members of the department have published numerous books ranging from textbooks at the second-year level, to research monographs.

The quality of the research produced by department members has led to the assertion that Memorial is a major research university in the mathematics and statistics scene. This assertion is supported by the following:

- members of this department are well-known to the NSERC establishment through their service on various NSERC committees such as Grant Selection Committees in all three disciplines and the Steering Committee for the Reallocation Exercise;
- members of this department have strong international academic links with many mathematics and statistics research centers as well as with many famous universities in the world (see below for details);
- members have won several prestigious awards for their research, such as two Memorial University Research Professorships (Brunner, Summers), a Dean of Science Distinguished Scholar Award (Booth), a Petro-Canada Young Innovators Award (Kokabiyik), and a Hall Medal (Rees);
- members of this department have served on editorial boards of many internationally recognized journals, such as, *IMA Journal of Numerical Analysis* (Brunner), *Journal of Computational and Applied Mathematics* (Brunner), *Journal of Integral Equations and Applications* (Brunner), *Mathematica Izvestia* (Bahturin), *Indian Journal of Mathematics* (Singh), *Journal of Combinatorial Designs* (Rees), *Canadian J. Statistics* (Sutradhar), let as well as refereeing for numerous other journals;
- and most recently, the appointment of B. Sutradhar to the eight-member international advisory board of Statistics Canada.

3.1. Research Grants and Contracts

Of the current 38 permanent faculty, 18 have NSERC grants. Summary data is provided in the following table. Effectiveness issues are considered in Section 7.2.

Table 3.1

Year	1994-1995	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000
NSERC Total	\$227,485	\$177,589	\$182,938	\$183,031	\$219,841	\$266,525
Number	15	15	16	17	15	20

NSERC operating grant data from *Academic Unit Profile 1998-1999*. Data for 1999-2000 taken from *Gazette* and includes faculty no longer here.

The individuals who are successful in obtaining NSERC support closely reflect the areas of strength identified in the previous section.

It is a departmental priority to increase the level of NSERC support. At the operating grant level, it is unlikely under the current NSERC *modus operandi* that the department will experience increases of more than 20 per cent in its total with its existing faculty complement. Significant increases would occur as a result of hiring, as they have in recent years where almost all of the recent increases can be attributed to new hires obtaining grants, some of which were significantly above the starter category.

Two members have contractual relationships with local industry and government. Again, it is a departmental priority to increase the number of contracts performed through actively seeking partners in industry and government.

3.2. Links to Other Units

3.2.1. Applied and Pure Mathematics

Academic Links: Due to their active research and academic involvement, mathematicians at Memorial have built strong links with many mathematics research centers in the world, such as Academia Sinica (China), Centre for Mathematics and Informatics (The Netherlands), Centre of Dynamical Systems and Nonlinear Studies (US), Weizman Institute (Israel). Members also have wide collaborative connections with mathematicians in many universities within and outside Canada, among which are University of California at Berkeley (US), Cambridge (UK), Moscow State University (Russia), Hamburg University (Germany), University of Trieste (Italy), University of Sydney (Australia), University of Wisconsin-Madison (US), to name a few. For a complete list, see the Appendix.

Interdisciplinary Links: On the other hand, due to the nature of the research in applied

mathematics, members in this group have also established some cooperative links with other academic units within and outside Memorial. One member in this department holds a joint appointment with the Faculty of Engineering and Applied Sciences; other members have performed joint research projects with C-CORE and the Institute of Marine Dynamics; another member is involved in an NCE-MITACS project on neural networks which is also an interdisciplinary research project funded by NCE and includes researchers from several fields (applied mathematics, physiology, clinical medical science, and electrical engineering) and from several universities in Canada and the USA (Calgary, Chicago, McGill, Memorial, Waterloo, and York). Members of this group contribute to the Masters Program in Computational Sciences. Applied mathematics seminars attract speakers and audience from other departments within Memorial and the community outside.

Industrial Partnerships: Industrial partnerships have also been built by mathematicians at Memorial. Research projects in such diverse areas as path planning for autonomous robotic activity, modeling fish stocks, iceberg trajectory forecasting, acoustic methods for estimating fish harvests, and acoustic methods for delineating the top 150 metres of the seabed, have led to strong links with government agencies and local high-tech companies, including, for example, Guigné International, Instrumar Ltd, and Oceans, Ltd. As an outgrowth of the NCE-MITACS, collaborations with the Department of National Defence and the company, Generation 5, have been established. The software developed by a member for ship motion prediction is currently being used commercially; he has also applied his expertise in the area to design, in consultation with the Department of Fisheries and Oceans; anti-roll tanks for local fishing vessels. Finally, a member collaborates extensively with the current holder of the NSERC/Certicom Industrial Research Chair in Cryptography at Waterloo.

3.2.2. Statistics

Academic Links: Statisticians in the department have built up collaborative links with fellow statisticians in many universities within Canada. In the USA, collaborations exist with faculty at the universities of Iowa, Maryland, Michigan, Missouri, Northeast Normal, Rochester, and Wayne State. External to North America, faculty collaborate with colleagues at the Indian Statistical Institute, Australian National University, Calcutta University, Sri Sathya Sai Institute of Higher Learning, University of Mauritius, and University of Suwon.

Interdisciplinary Links: Statisticians have also been doing fruitful collaborative research over the years with faculty members from other departments and faculties at Memorial, such as Biochemistry, Engineering, Health Sciences, and the Marine Institute.

Industrial and Government Partnerships: Working partnerships with large research organizations such as Statistics Canada, Health Canada, Fisheries and Oceans, and the National Center for Atmospheric Research in Colorado exist and will be strengthened in the future. One such partnership generated a large CFI grant that will be used to perform experiments on fish harvesting methods and analyze the resulting data.

4. UNDERGRADUATE PROGRAMS

The department offers programs in pure and applied mathematics, and statistics. Majors and honours degrees are offered in all three areas, in addition to minors. As well, the department has cooperated with many other departments in the Faculty of Science to create joint degrees.

Substantial enrollment data is contained in the *Academic Unit Profile 1998-1999*. For comparison purposes, we present Tables 4.1 and 4.2 below that combine data on US public universities with that from Memorial¹³.

Table 4.1

Type	GRIA (%)	GRIB (%)	GRII (%)	GRIII (%)	MUN (%)
Remedial	8.9	8.1	7.3	16.9	9
Precalculus	11.4	21.7	23.6	19.6	26
First-year Calculus	39.9	34.7	30.6	23.5	27
Statistics	2.9	2.9	4.0	8.3	19
Courses for Majors	18.9	18.8	13.7	10.4	17
Other	13.8	11.0	17.3	17.9	0
Graduate	4.2	3.1	3.4	3.4	1

Table 4.2

Type	GRIA	GRIB	GRII	GRIII	MUN
Undergraduate	7,789	5,938	4,696	3,437	4,129
Graduate	338	192	165	121	121

In terms of total registrations, Memorial could be considered either a large GrIII university, or a small GrII university. In terms of registration percentages associated with majors, we most closely resemble a GrI public university.

The *Academic Unit Profile 1998-1999* also contains data on majors. Table 4.3, presents data on the total number of majors derived from internal departmental sources and degrees conferred. A complete breakdown of all majors by year and subject area is contained in Table 4.4 (overleaf).

¹³Data on US universities from *Towards Excellence: Leading a Doctoral Mathematics Department in the 21st Century*, p. 17. Memorial data from Fall 2000.

Table 4.3

Year	1995	1996	1997	1998	1999	2000
Number of Majors	289	234	204	170	182	170
Number of Graduates	47	34	70	46	45	--

While the trends are identical, the total number of majors in the internal data are larger by approximately 70 per cent in comparison to the same number in the *Unite Profile* data. This discrepancy is due to the fact that the *Academic Unit Profile 1998-1999* data counts only the major of first registration and not joint majors¹⁴. Since many of our majors do not come to our programs until later in their university careers, they do not show up in the *Academic Unit Profile 1998-1999* database. That said, the observed decline is a matter of concern and will be discussed further below.

Table 4.5 presents a breakdown of section data between mathematics and statistics at the various levels. As the data shows, the number of sections taught has been reasonable stable in the mid 170s over the past five years.

Table 4.5

Year	1999-2000	1998-1999	1997-1998	1996-1997	1995-1996
First Year (ex MLC)	80	79	78	77	77
Stats 2000	20	20	17	17	16
Math 2000+	57	57	60	64	63
Stats 3000+	10	11	11	13	12
Math Grad	6	1	5	1	2
Stats Grad	4	2	4	5	4
Total	177	170	175	177	174

¹⁴There are also small discrepancies between the two data sources in the number of graduates for which we cannot account.

Table 4.4

Year	Applied Mathematics						Pure Mathematics						Statistics						Total UnG
	Y2	Y3	Y4	Y5	Hon	Total	Y2	Y3	Y4	Y5	Hon	Total	Y2	Y3	Y4	Y5	Hon	Total	
2000	9	25	21	12	3	67	11	31	20	24	5	86	0	2	11	5	2	18	170*
1999	12	20	22	24	5	78	6	29	24	30	6	89	0	2	10	3	1	15	182
1998	7	31	18	18	7	74	12	27	16	25	6	80	2	8	2	4	1	16	170
1997	11	19	24	28	8	82	15	21	31	38	9	105	6	3	2	6	5	17	204
1996	10	29	27	33	6	99	13	30	38	38	7	119	2	2	3	9	5	16	234
1995	18	34	42	9	2	103	28	53	41	34	3	156	3	4	8	15	5	30	289

**One student is enrolled in PMAT/STAT joint honours.*

Numbers of majors and honours students from 1995 to present. Information taken from majors list for fall semester.

Table 4.6 presents a breakdown of who teaches the sections¹⁵. The reduction in the percentage of courses taught by regular full-time faculty over the period is an obvious concern.

Table 4.6

Year	1999-2000	1998-1999	1997-1998	1996-1997	1995-1996
Total # of sections taught by regular full-time faculty	130 73%	120 71%	111 63%	132 75%	148 86%
Long-term contractals	4	4	15	8	4
Short-term contractals	5	3	0	9	0
Per-course appointments	21	23	28	21	18
Graduate Students	13	17	17	4	1
Extra Teaching	4	1	4	1	2
Total	177	168	175	175	173

The reader will notice the increase in the number of sections taught by graduate students, particularly in last three years. This reflects a policy implemented by the current head, to increase funding to graduate students through sessional teaching, while simultaneously providing cost-effective instruction of high quality. This policy, is consistent with the policy articulated in a speech given by the vice-president (academic), Evan Simpson, on graduate studies at Memorial (see A4.1).

4.1. Applied, Pure and Statistics Programs

The Department of Mathematics and Statistics offers numerous undergraduate programs. Rather than attempt a description of these and the courses that make them up, the *Undergraduate Guide 2000-2002* is included as A4.2. A brief submission articulating undergraduate issues in respect to statistics is included as A4.3.

In terms of the department's teaching efforts, something over 40 per cent, on a section basis, is associated with delivery of its programs (see Table 4.5).

As we have noted above, maintaining the size of our major cohort is a concern. Table 4.4 presents a breakdown of registered majors by program going back to 1995. In Table 4.4, joint majors are included with the area of specialty, so that a joint pure mathematics/computer science major would be included under pure math; the total is the total majors, some of which are honours students.

¹⁵The discrepancies between the totals in Table 4.5 and Table 4.6 are due to the fact that the department shares responsibility for the teaching of some courses with other departments.

To address declines in majors and graduates, at the suggestion of the vice-president (academic), the Department of Mathematics and Statistics tried sending letters of recruitment to outstanding students; our experience appears consistent with that of other departments - not much effect is observed. What does seem to be of positive benefit, at least according to case studies, is providing an excellent educational experience, particularly in entry-level courses. The department is constantly looking for ways to improve the educational experience, for example, by introducing a Career Night. However, implementing the types of solutions identified elsewhere involves resources the university has, so far, been unwilling to supply (see *Towards Excellence: Leading a Doctoral Mathematics Department in the 21st Century*).

4.1.1 Renewal

The Department of Mathematics and Statistics struck a committee to review its undergraduate programs in the late fall of 1999. This committee is composed of four members: one faculty member from each of pure mathematics, applied mathematics and statistics, and one student representative. At the time the committee was formed, this student was a senior undergraduate student, but he is now a graduate student in the Department of Mathematics and Statistics.

The committee surveyed the faculty and students in the Department of Mathematics and Statistics to determine some of the strong points of the programs, what aspects could be improved, and what could be done to increase the number of major and honours students. The committee also sought input from other departments in the university to determine if their students were required to take courses offered by the Department of Mathematics and Statistics, and if the courses were meeting their needs.

The responses showed that there were some problems in the undergraduate program that should be addressed. One major issue was the difficulty students have with the transition from the computational-intensive early courses in calculus (M1000, M1001, M2000) and linear algebra (M2050) to the more theory-oriented courses in these topics (M2001, M2051, plus other third-year courses).

Based on these and other issues raised by faculty and students, the committee is finalizing a set of core courses that would be required of all majors in the Department of Mathematics and Statistics. Some of the ideas of the core curriculum have already been presented to, and discussed, by the department. It is hoped that this core curriculum will give all majors a solid grounding that will lead to success in their advanced courses. The major and honours degrees will then be modified around this core curriculum. Naturally, the input of the faculty members in each of the three subdisciplines in the Department of Mathematics and Statistics will be vital to create programs that are academically strong and will appeal to potential majors.

4.2 Entry-level and Service Courses

As shown in Table 4.1, approximately 80 per cent of the department's registrations are in the categories of entry-level mathematics, statistics and remedial. Although these categories do not

include all service registrations, not all registrations included are actually service, so that 80 per cent is a reasonable estimate of the proportion of the department's registrations that could be classed as service¹⁶. It should be noted that the department has essentially no control over its service teaching requirements which are set at the initiative of client units¹⁷.

The fact that so much of the department's teaching effort is to students aimed at other programs reflects the nature of mathematics as a **central discipline**. The simple fact is that most other disciplines require some training in mathematics and, or, statistics as part of their major programs.

Past reports critical of teaching practices extant in these courses establish that there is concern both in society generally, and throughout the university, in respect to the quality of instruction provided by the department. That these concerns continue to this day is reflected in a report prepared for the vice-president (academic) by S. Singleton titled, *High School Graduates ® First-Year Mathematics at Memorial =? Status of First-Year Mathematics at Memorial University* and also in a government document titled *The High Failure Rate of First-Year Students in Introductory Mathematics at the University and College*, which are included as A4.5. The report begins by noting that students who fail first-year mathematics are generally not retained, whereas students who pass first-year mathematics generally are retained. Thus, what happens to students in first-year mathematics is critical to their success and to the overall success of the university's retention strategy.

Student Sources. The overwhelming majority of students entering Memorial come from the Newfoundland School system. In respect to mathematics, they come from either the academic or the advanced stream. In fall 2000, approximately 2,300 students entered Memorial. Of these, about 1,100 had completed the academic stream and a similar number the advanced stream. An additional 60 students had completed AP Calculus.

At the present time, the school system is expected to produce approximately 3,800 students who have completed academic math and 2,300 that have completed advanced and a much smaller number that have completed AP Calculus¹⁸. A total of about 2,600 of these students attend Memorial at its two campuses, 1,250 from advanced and 1,350 from academic.

4.2.1 Entry-level Mathematics Courses

Courses included in this list are: Differential Calculus (M1000), Integral Calculus (M1001), Precalculus (M1090) and a pair of courses for primary and elementary teachers and arts students (M1050/51). The current structure was put in place after thorough consideration of the Senate Report that has already been referred to (A1.10). The elements are discussed briefly below.

¹⁶This total is consistent with the experience of other departments (see *Towards Excellence*, p. 129).

¹⁷A4.4 contains information in respect to a request from the School of Physical Education and Athletics. The position of the dean is clear, he wants the registrations. It is also clear that additional resources will not be forthcoming.

¹⁸Data derived from a letter from P. Gosse who was the mathematics consultant for the Avalon Consolidated School Board and also a member of the Mathematics Learning Centre (MLC) review committee.

Placement. Figure 1 illustrates the flow of these students into courses on the St. John's campus from the courses in the high school system.

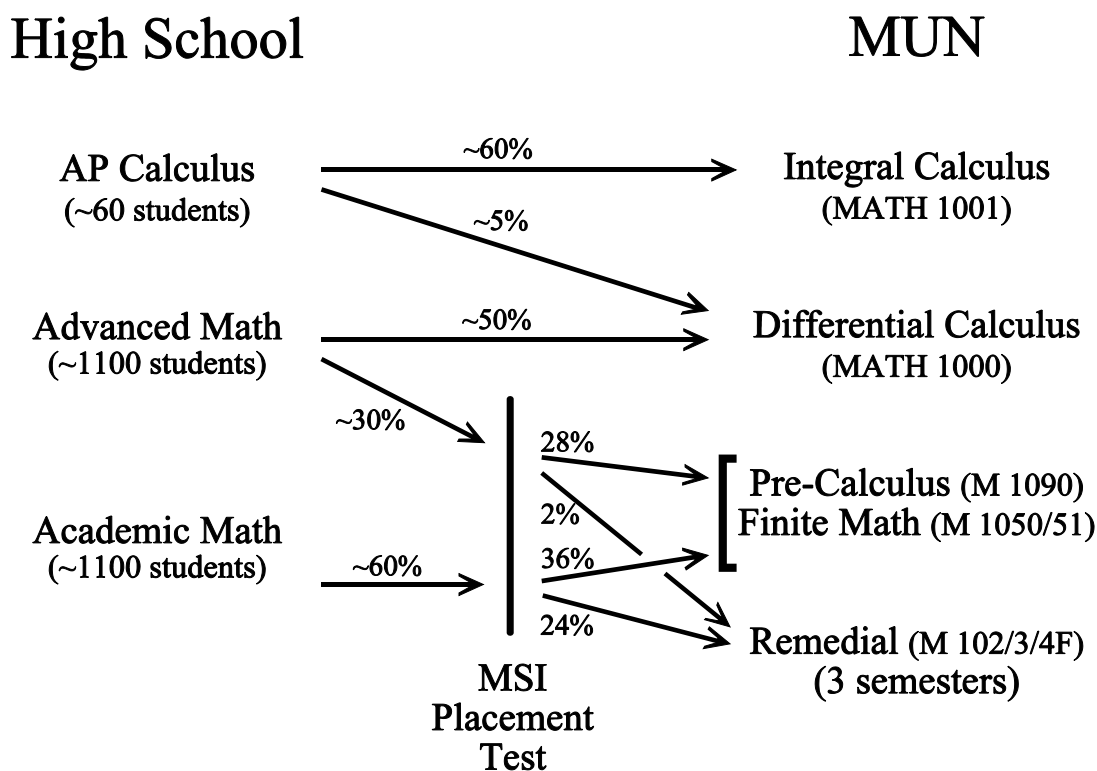


Figure 1

Students who have completed the AP exam with at least a three are given direct admission in M1001 and credit for M1000. Their success rate in M1001 approaches 100 per cent, with very high grades.

Students from the advanced stream are given the choice of direct admission to M1000. Their success rate in M1000 exceeds 80 per cent. A proposal, which could only benefit students, was made to give credit for M1090, on successful completion of M1000, to students who had a high score on the SAT II Level IC subject area test. This proposal was sent back by the Faculty of Arts.

All students seeking entry to M1090, M1050 and M1051 must write a placement test, the Math Skills Inventory (MSI). This test is very low-level, and a sample is included in A4.6. Effective in

1998, placement became mandatory and students not achieving the cutoff mark (at present 50¹⁹) are required to go to the MLC (see below).

Two additional things stand out in Figure 1. First, almost none of the students from advanced math require remediation. Second, approximately 40 per cent of academic students require remediation. Moreover, while the high school average in math of students in the academic stream is in the 70s, the mean score on the MSI is some 22 points lower. On the other hand, the high school math average for students from advanced is also in the mid 70s but performance on the MSI is only seven points lower, even though this group contains only the weakest students from the advanced stream.

Remediation. The program of study offered at the MLC was designed by Rudy Zimmer at the Fanshaw College and has been used and further developed by at Memorial for more than 10 years. The MLC underwent a review in May 2000, and the report is included as A1.5. There are significant concerns in respect to the program offered by the MLC. To be specific, students getting less than 50 on the MSI are operating at about the grade six or seven level mathematically. The program of instruction that attempts to repair this damage is designed for two semesters (non-credit), and typically takes three for students here. This is seen by non-mathematicians to be an absurdly long length of time. Such perceptions entirely ignore the fact that the school system did not solve the problem for these students in a period of six years. The concerns and related matters are articulated in a memo from the vice-president (academic) to the Senate Committee on Undergraduate Studies on the issue of retention which is included as A4.7. Students continually raise the point that the courses are non-credit, a fact that affects motivation, and hence, success. Proposals by the department to remedy this situation by giving limited credit for the courses were killed by the Faculty of Science.

Retention. It is evident that if Memorial wants to increase retention rates the simplest way to do it is to attract additional students that can succeed in Memorial's courses. Quite clearly, there is a pool of students taking advanced math in high school that do not currently come to Memorial. Individuals within the Department of Mathematics and Statistics have argued for years that a scholarship program that places AP courses on the same plane with advanced courses, which are again on the same plane with academic courses, is counterproductive. It is a fact that the best students, who take a full load of very difficult AP courses, will be unlikely to reproduce the same high grade average of students who are taking the weakest academic courses to achieve a high average for scholarship purposes. Yet it is a fact that students from the academic stream are awarded scholarships and end up having the complete remedial courses, while students who have completed AP courses must go elsewhere to get the scholarship recognition they deserve.

New Atlantic Curriculum. It is argued that the new curriculum being implemented in the provinces of New Brunswick, Nova Scotia and Newfoundland will solve the problem. No university level mathematician who has studied the curriculum documents agrees with this contention (letters

¹⁹The mark of 50 was found to be effective in producing ensemble pass rates of 80 per cent in M1050 and M1051, but not in M1090. The cut-off mark for entry into M1090 will be 55 effective Fall 2001, and the decision will be reviewed in two years time.

reporting the concerns of the Department of Mathematics and Statistics to the Department of Education are included as A4.8).

The new curriculum reduces time on task in Grade 10 for students in the academic stream by 33 per cent. Curriculum issues aside, it is hard to understand how reducing the time on task for the students in the academic stream, that are known to be at risk, will bring them to a higher standard.

The Department of Mathematics and Statistics has had a representative on the curriculum materials review committee for the past three years. The main thrust of her work has been to provide comments on the accuracy of materials. Her time appears to have been wasted since few of the numerous factual errors she identified appear to have been fixed in the revisions being sent to students (see material in A4.9). It is a sad fact that the students taking this new curriculum, however ill thought out, will not even be permitted to study from materials that are factually correct.

Given this situation in respect to the new curriculum, it is hard to see that the mathematical quality of students entering Memorial will improve in the near term.

4.2.2. Statistics Service Courses

Statistics service courses are presently taught in sections of 90. Each section has three labs attached, each of 1.5 hours duration. The labs are generally not taught by the course instructor. It is also the case that significant numbers of sections are taught by sessional, or temporary contractual, instructors who have no connection with the university beyond their teaching responsibilities.

There have been, and continue to be, concerns raised about the quality of instruction in these courses. Indeed, early on in the first term of the current head, the head of the Department of Biology proposed to the Dean of Science that statistics should be disbanded and taught in the user units, e.g., biology, psychology, business, etc. Given that other departments are able to invest far greater resources in the teaching of entry-level statistics, it is not hard to understand the rationale for such views.

4.3. Advising

The Department of Mathematics and Statistics employs an undergraduate advisor. The individual occupying this position taught here at first year in the 1980s and then spent a number of years teaching at the College of the North Atlantic in Grand Falls before returning to the department in the fall of 1997. This individual handles all registration of majors and honours students and is responsible for advising all students completing programs in applied or pure mathematics. He also deals with all entry-level advising. In addition to his advising duties, he advises the head in respect to planning future offerings and serves as secretary to the Undergraduate Studies Committee.

Advising statistics majors is the responsibility of the deputy head, who is a statistician.

Because the department has reduced the number of individuals providing advice to students, it has been able to ensure that there is a uniform quality to the advice provided. As well there is continuity because of the permanent nature of the undergraduate advisor position.

Placement. The introduction of placement has created a major additional advising burden. This starts with students and parents requesting information prior to coming to Memorial, and continues for students who do not gain entry to the course of their choice. This burden is shared between the undergraduate officer, the head, and the director of the MLC, as appropriate.

4.4. The Mathematics Learning Centre

The MLC is administered by the Dean of Science, although the Department of Mathematics and Statistics is academically responsible for its courses. This fact demands close cooperation between the head of the Department of Mathematics and Statistics and the director of the MLC, Dr. Sherry May. Some key operational problems for the MLC are set out in A4.10.

Aside from being responsible for providing remedial instruction in mathematics, the MLC conducts research on the effectiveness of remedial instruction and is continually developing new learning materials. As well, the MLC has a number of outreach programs aimed at trying to solve the remediation problem before students come to Memorial. Three deserve mention (see A4.11 for more information).

First, the MLC has a program of hiring teachers in training to work at the Centre. The purpose is to educate future mathematics teachers as to the remedial problem so they can take this experience with them into the schools.

Second, the MLC has a program of hiring teachers from the local community at the Centre. The purpose is to educate existing mathematics teachers as to the remedial problem so they can take this experience with them into the schools.

Third, the Centre has developed a cooperative program, *Operation Foresight*, with O'Donel High School to identify students who want to pursue post secondary instruction and who are in need of remediation in mathematics. The purpose is to solve the problem before the students come to Memorial, or any other post-secondary institution.

4.5. Outreach Programs

Waterloo and Blundon Contests. The university of Waterloo runs a series of national contests in mathematics at all grade levels starting in Grade 8. The Department of Mathematics and Statistics is the agent for the contest in Newfoundland and our responsibilities include some grading of exam papers.

The Department of Mathematics and Statistics also runs its own contest for students in Grade 12, the Blundon. All aspects of the Blundon are run by department members.

High School Seminar. On an annual basis the department runs a two-day seminar for mathematically able students from around the province. Students are identified based on performance on the Waterloo exams. This program is universally enjoyed by the students who attend.

Math League. Math League is a program for senior high school students. Four times a year the students meet and teams of four from participating schools compete at a problem solving. The program was initially established in St. John's in the late 80s. It expanded to most of the province and there is now a version running on the web.

Junior High Challenge. This is a program in which challenging problems are submitted to participating classes at the junior high level. Solutions are submitted and graded by participating department members.

4.6. Quality Issues

As has been noted the Department of Mathematics and Statistics has been subjected to various reviews that raised concerns about the quality of instruction being provided. Most recently, the Department of Mathematics and Statistics, through a collegial process, responded to the Senate Report (see A1.9–10). The response required a year of deliberation. All facets of the instructional process were considered, including curriculum, format of delivery, placement and so forth. In its thinking, the Department of Mathematics and Statistics tried to operate on a stable budget model, that is, the notion of returning to small classes as a solution was discarded for administrative reasons, not pedagogical reasons. We are well aware of the literature on the positive effect of teaching mathematics in small classes (see department models in *Towards Excellence: Leading a Doctoral Mathematics Department in the 21st Century*).

4.6.1. Class Size

As noted in the history section, class sizes rose throughout the eighties. A bound of 70 (initial registration) was established and reconfirmed in the Senate response document for first-year classes other than fall classes of M1000 where the bound was 100 (see A1.10). In addition, where graduate students are teaching sections, the bound is set as 40 (60 in statistics sections having labs).

4.6.2. Laboratories

The poor quality of the laboratory experience was cited by almost all contributors to the Senate Report (A1.7). At the time of the report, graduate students, many of whom had very poor skills in English, were running the labs. This practice was ended in mathematics courses and labs are now again taught by the faculty member teaching the course, thereby making a single instructor responsible for the quality of the learning experience. This implements recommendations in a 1995 Report (see A4.12).

In statistics, the practice of using graduate students to staff labs continues, except where the course instructor is a graduate student; in that case, the lab instructor is the course instructor, who happens

to be a graduate student. The reason that faculty course instructors are not teaching the labs in statistics is a lack of resources. There are simply not enough statisticians on staff to permit this. One effect of this is that there is a very limited ability to develop a quality lab experience in statistics. Needless to say, this has resulted in concerns in user departments, particularly Biology.

4.6.3. Instruction by Graduate Students

Before a graduate student is permitted into the classroom, he must give a teaching lecture²⁰. The purpose is to evaluate language skills and to make a judgment as to whether the student can cope with a class. Once classes start, the graduate student's class is visited by faculty and tests are reviewed prior to their administration.

In the rare event that problems are detected, additional support mechanisms go into play. These include additional visits, having the student instructor attend the class of a successful peer, and any other steps that can be taken to improve the instructional experience for the students and the instructor.

Since classes taught by graduate students are capped at 40 (60 in statistics), it is possible to begin reducing class size to improve on this quality variable.

4.6.4. Use of Sessionals

Because the Department of Mathematics and Statistics has not been permitted to hire faculty consistent with its offering, the department has been forced make substantial use of sessional instructors hired through ads in the local papers. In this context, a sessional is defined as an individual providing instruction on a per-course, or contractual, basis whose only relationship to the department is to provide that instruction. Short term contractals also fall in this category, because short term contractals are hired from the sessional pool and are only hired when sufficient teaching cannot be obtained on a per-course basis. The reason that short-term contractals are avoided is that short term contractals become part of the union and must be paid at higher rates. As can be seen from Table 4.6, approximately 25 units of teaching are covered on this basis annually, which translates into something over six regular faculty positions.

While these instructors do the best possible job in the circumstance, they can do little other than cover a syllabus. In short, they can make no contribution whatsoever to the department beyond the provision of instruction to the students in their class room. In the department's view, the only thing this instruction has going for it is that it is cheap.

That dependence on sessionals can negatively effect students is witnessed by the fact that the department was unable to meet the demand for entry-level statistics in the fall 1997 semester. It is likely that that particular situation will soon recur.

²⁰The vice-president (academic) struck a committee, chaired by W. Barker, to evaluate the feasibility of using graduate students in the classroom. Some of the concerns raised in Barker's report (see A4.13) are addressed by the activities discussed here.

4.6.5. Numbers of Sections

There is an expectation from senior administration that units will put on the fewest number of sections required to meet demand. To effect this, the department starts by opening fewer sections than the estimated demand, and opens additional sections on the basis of wait lists. Sections opened later are seldom in good time slots due to a shortage of classrooms, so that sections opened late are often undersubscribed due to time conflicts for students, even though the demand was there. This policy results in many more complaints about instructional quality than would be the case otherwise. These are primarily due to students finding an instructor unsuitable, followed by an inability on the part of the department to move the student to a new section, as we would have done in previous times that were less financially strained.

4.6.6. Pressure from the Dean of Science

The experience of the current head of department in respect to entry-level courses is that there is continual pressure from the dean's office to raise class size as a means of effecting economies. As evidence of this, a memo dated July 14, 2000 from the current head to the dean that responds to proposals from the dean (attached to the memo) as to how to effect savings on instructional costs (see A4.14). The memo relates to the re-appointment of the head, but makes clear the nature of the conflict between the department's desire to maintain and/or improve the quality of its instruction in entry-level courses and a dean of science that would have the department reverse all the steps taken in response to the Senate Report in an effort to effect savings.

It is the perception within the head's office that when it comes to the allocation of resources, the dean assigns the lowest priority to quality issues related to entry-level teaching performed by the department. While it is understood that the dean has a responsibility to set priorities for the Faculty of Science, the conflict between the departmental responsibilities set by client departments and the minimal resources allocated by the dean to deal with these responsibilities is real²¹.

It is a matter of some frustration that the push for savings does not seem to apply to other departments in the Faculty of Science teaching the same subject matter. To take an example. Another department in the faculty teaches entry-level statistics to its majors in sections of 100 with four three-hour labs of 25 students each taught by the course instructor. In the fall semester 2000, university records available on the Banner system show this course offered to less than 75 students with all four labs running. Obviously, a three hour lab with less than 20 students is a more effective learning environment than a 1.5 hour lab with 30 students and leads to the conclusion, in comparison with other departments, that the Department of Mathematics and Statistics has only minimal interest in providing quality instruction.

A complete analysis of the this problem is presented in Section 8.

²¹See A4.4 for an example.

5. GRADUATE STUDIES

The department offers graduate programs in pure and applied mathematics and statistics at the masters and doctoral levels. These programs are fully described in the *Graduate Handbook 2000-2001* which is included as A5.1.

Enrollments, including part-time students, for the past five years are presented in Table 5.1. More detailed data is contained in the attached report, from the Graduate Studies Committee and Statistics Group (see A5.2).

Table 5.1

Year	2000	1999	1998	1997	1996
M.Sc. Pure & Applied Math	4	1	0	1	0
M.Sc. Statistics	5	3	0	2	2
MAS	4	5	4	5	4
PhD Pure & Applied Math	4	4	4	8	9
PhD Statistics	2	2	2	1	1
Total	19	15	10	17	16

As already noted, it is a departmental goal to substantially raise these numbers.

5.1. Expanding the Program

The keys to building a graduate program are as follows. First, the department must have sufficient research faculty to maintain the program. Second, we must offer a competitive financial package to attract students. Third, we must have a successful strategy for recruiting students. The problem of faculty requirement is dealt with in Section 8. The others are addressed below.

5.1.1. Financing

Graduate student support at Memorial, in most cases, comes from only three sources: the department's budget in the form of TAs (\$2,250 per student per year); Memorial graduate fellowships awarded by the School of Graduate Studies as *baseline support* (now \$7,000 per year per student); contributions from the supervisor's grant (now typically \$3,000 per year).

It is clear that in order to increase the number of graduate students the department must obtain support from both the Faculty of Science via its operating budget to increase TA support, and also from the School of Graduate Studies to increase baseline support. It is important to note in this context that the dean of the School of Graduate Studies has generously supported an increase in the

department's baseline support, that is, the number of available fellowships, to achieve the departmental objective of expanding its program²². A similar commitment has not been forthcoming from the dean of science. Perhaps this has something to do with differences in the funding models. The School of Graduate Studies provides fellowships as they are needed, i.e., as students are admitted. TAs are provided as line items in each department's budget, as opposed to a pool for the entire Faculty of Science. This leaves less flexibility at the faculty level but more at the department level. In any case, a commitment to increase the department's TA budget will be needed if the department is going to significantly expand its program.

Increasing the Package. As things stand, a typical package from these sources is approximately \$12,250. Such a package is not competitive in the North American context where typical funding is in the range of \$20,000 annually.

The notion that an \$8,000 deficit can be made up from any of the sources mentioned above by enlarging the contribution, appears not to be practicable given the policy being promulgated by the vice-president (academic). One acceptable alternative is per-course teaching, which is now paid at a rate of \$3,800 per course. Using this source, a graduate student teaching two sections per year receives a total package of almost \$20,000. The amount is competitive. The graduate student obtains experience as a teacher; the department receives additional teaching support from individuals with a commitment to the department in terms of their own educational experience. It is a win-win situation at all levels. This is the approach the department has taken to providing a competitive financial package, and it has been well-received by students in our program during the past three years. Having said this, the department's Graduate Studies Committee is exploring the possibility of increasing the amount of individual fellowships with the School of Graduate Studies.

5.1.2. Recruitment

We believe successful recruiting is dependent on finding sources of students not accessed by other universities. The point here is that the larger universities with more established programs actively recruit Canadian students, for example, the PIMS recruitment weekend in the early winter that flies senior students from all over Canada to Alberta or British Columbia. While the department continues to be interested in attracting Canadian students and will continue to recruit within our means, e.g., by circulating information on our programs, something more is needed.

The department has an international faculty, many of whom come from countries where English is the language of instruction at their universities. A potentially successful strategy for attracting students can be based on using international contacts to identify quality students to train at Memorial. Such students, who couple mathematical and/or statistical talent with skill in English are well positioned to participate in a graduate program where students contribute to providing

²²The authors of this report believe that one reason that the dean of the School of Graduate Studies has been willing to provide increased support is due to the department's efforts to make the program cost neutral by using graduate students in the classroom. Inspection of Barker's report (A4.10) suggests that this department may be unique in the Faculty of Science in believing that graduate students should teach.

undergraduate instruction. It is believed that such a strategy coupled to a program built around an outstanding faculty can succeed in attracting excellent students from the targeted cohorts. This is the strategy that the department is adopting.

6. ADMINISTRATION

Figure 1 presents an organizational chart for the Department of Mathematics and Statistics. In outline, the discussion below will follow that model.

6.1. Head

Overall responsibility for administration of the department falls to the head, Dr. Herbert Gaskill. He was reviewed prior to his second term which started August 1, 2000. The report of the Review Committee and dean's memo are included as A6.1.

6.2. Administrative Support

Dr. Gaskill is directly supported by a secretary, W. Heath and an administrative staff specialist, R. English, who deals with budget and financial affairs. In the opinion of the head, these two provide outstanding service to the head, and more generally, to the department.

6.3. Faculty Support

The department has two secretaries, P. Kavanagh and L. Morrissey, who deal primarily with faculty and students. They are nominally responsible to R. English, but most directly responsible to faculty. There is general universal agreement among faculty that the level of service provided by these two individuals is excellent.

While the volume of service provided is adequate to support a faculty complement of 40, if the department returns to a size consistent with its present load and the graduate program expands, an additional position will be required.

6.3.1. Computing Facilities and Support

Computing is an extremely important resource, both for teaching and for research. The department has more than 100 computers, including, individual systems in offices, servers, a computer lab with 32 machines, and a Beowulf Cluster having 50 nodes. All of these exist on a network having a bandwidth of between 10 megabits and one gigabit per second, depending on the part of the pipe being examined.

To be useful, computers must work reliably and this implies strong support. Computer support is supplied through a contractual agreement with the Department of Computer Science. Positions exist as line items in the department's budget, but the individuals in computer support positions work for the Support Group within the Department of Computer Science. This agreement provides access to a much larger volume of expertise and experience in all aspects of computing and enables the department to take advantage of computing innovations introduced in the Department of Computer Science, at the earliest possible time. It also reduced the load on individuals associated with maintaining function on a 7×24 basis. The manager responsible for these systems is C. Squires. It

is generally agreed that while the service provided is excellent, the volume of service available is inadequate. The department needs at least three full-time positions as opposed to the 1.5 permanent positions and one unfilled contractual position that it presently has. This estimate assumes a continued cooperative agreement with the Department of Computer Science. Should that agreement be terminated as suggested in a memo from the dean of science (see A6.2 for E-mail and response), a larger complement will be required.

6.4. Space

Inspection of the department's physical environment reveals that every square inch of space is used. Offices are cramped, with the average size office being less than 120 sq ft; university average for faculty offices is just under 150 sq ft. Storage space for department records is almost non-existent. Expansion of the graduate program is impossible without more space (see A6.3 for details).

A space plan was developed and submitted as part of a space review process that was initiated after the department requested additional space to house graduate students and retirees. The plan is included as A6.4. The report of the university review is included as A6.5. The request was denied on the grounds that the university has no additional space.

A proposal has been put forward in concert with the Department of Computer Science for a building of approximately 3,500m² to provide for expansion of the two departments. The response from the university, was a clear statement by the vice-president (research) that the priority was for life sciences (see A6.6)²³.

6.5. Administrative Review

A review of the administration of all departments in the Faculty of Science was conducted during fall 2000. The draft report on the department is included as A6.8.

6.6. Budget

A2.6 contains Tables 1-4 of the department's initial 2000/01 budget submission. A2.7 contains the same tables for the revision required by the dean. A6.9 contains the budget allocated by the dean and a background item showing how budgets were obtained for the faculty. Table 1 contains summary information.

Table 6.1

²³Since the dean of science recently also stated that a new life sciences building was a very high priority for him, it seems unlikely that a building to support research in the mathematical and information sciences will ever be built. This said, as the budget for a workshop in algebra shows, the university and the dean of science do provide some support (see A6.7).

	February 15	Revision	Dean's Allocation
Salaries	3,406,001	3,106,116	3,106,116
Operating	224,847	224,847	198,847
Capital	26,412	0	0
Total	3,657,260	3,330,963	3,304,963

Although the budget allocated by the dean increased from the 1999-2000 actual expenditure by approximately \$70,000, it is a fact that the increase did not cover additional costs over which the department had no control, e.g., salary increments²⁴. It is also the case that the department will run an apparent deficit in the current budget year associated with having to reinstate sections that were canceled in going from the initial submission to the revision. A complete analysis of the budget of the Faculty of Science, based on all available data, is contained in Section 8.

6.7. Teaching Loads

Teaching load is set by the head and is governed most particularly by Articles 3.10, 3.11, 3.13, 3.16, and 3.17 of the *Collective Agreement*. These sections are included as A6.11.

The teaching load in the Faculty of Science is four three-hour lecture section equivalents per year (*Collective Agreement* 3.10), with a provision to raise to five on the basis of little or no research productivity (*Collective Agreement* 3.17b).

Articles 3.16 and 3.17 require the head to account for alternative formats, four hour courses and labs, class size, and supervisory responsibilities in determining the teaching assignment of faculty. While past practice has, for the most part, ignored most of these items in load calculations, this will not be possible under the new contract because of recent grievances.

A reasonable guess at the number of three-hour lecture section equivalents that would result from a proper accounting of the teaching work of the department on an annual basis under the terms of the *Collective Agreement* would be in excess of 230²⁵.

²⁴The big source of increases was associated with paying salaries for the entire year of newly hired faculty (see A6.10).

²⁵This calculation includes labs, four-hour format and supervision of 20 graduate students, but not class size. The formula for labs and supervision was extracted from material circulated from the dean's office during the last budget round. The formula for four-hour courses approximates the formula generated by an arbitration on this issue. Comparison of Table 2 in A2.6 with that in A2.7 shows a reduction in calculated teaching tasks from 226 to 185. The task counts in the first submission accounts for labs and supervision, but not four-hour format or class size. In the second submission no credit is given for supervision.

To cover 230 teaching tasks with regular faculty that are entitled to sabbaticals would require approximately 68 faculty²⁶. The department's proposal is for a complement of approximately 50 regular full-time faculty with sufficient faculty and graduate students to be able to cover teaching commitments and meet the university's commitment to providing quality undergraduate instruction.

²⁶It is assumed that all faculty are research active and would take a sabbatical every seventh year.

7. EFFECTIVENESS

This section provides information of effectiveness.

7.1. Instruction

Elsewhere in this document, information has been provided on student numbers, graduation rates from the department's various programs and so forth. None of these provide information on the satisfaction of the students to whom the instruction is provided.

In order to assess instructional effectiveness, from a student perspective, a survey was conducted of all graduates of from the department in the past five years (104 responded), 100 graduates that had taken two or more courses in the department but did not pursue a degree from the department, and five recent advanced degree graduates.

The entire report is contained as Appendix A7.1. While the report is generally gratifying to the authors of this document, there are areas identified for concern, e.g., career counseling. The reviewers are left to ponder whether some of steps taken in the past few years are adequate responses to the concerns identified.

7.2. Research

Memorial classifies itself as a *comprehensive* university.

Defining research and its contribution to society for comprehensive universities is problematic as can be seen from inspection of the literature on the subject²⁷. What is clear is that a broader definition has to be taken in the context of a comprehensive university than the narrow production of new knowledge in the discipline²⁸.

Having admitted that developing a definition is problematic, developing success measures is even more so. In the end, one concludes that the most effective measures of success are most likely associated with comparisons.

After much reflection, there are two possible sources of comparative data. The first is data from those universities with which Memorial seeks to compare itself, namely: Dalhousie, McMaster, and the Universities of Calgary, Manitoba, New Brunswick, Saskatchewan, Victoria and Waterloo. Alternatively, the department can compare itself with other units within the university.

²⁷See *A New Model for Classifying University Research* by O.D. Hensley and L.R. Jauch, in *The Classification of Research* edited by O.D. Hensley, Texas Tech University Press, 1988.

²⁸A book circulated by J. Tuinmann, the previous vice-president (academic) titled *Scholarship Reconsidered: Priorities of the Professoriate* by Ernest Boyer discusses the changing nature of scholarship in a modern university. A principal thesis of this work is that a far broader definition of scholarship is essential.

In preparing this report, comparison data on publication rates were sought. This proved fruitless for two reasons. First, so far as the authors can tell, there is no data on average publication rates in mathematics and statistics for the universities in the comparison group. Second, the data held by this university on which comparisons between departments might be based is considered so unreliable as to be useless for the purpose²⁹.

After discussion with the Office of Research, Debbie Barnes supplied data on the average size of grants for universities in the comparison group. The data supplied by the Office of Research is contained in A7.2. Table 7.1 contains information on average grant size (in thousands of dollars) by granting council for the 24 committees in which Memorial competes, together with the number of grantees. There are also two calculated data sets, namely, in the third column the percentage of the Memorial average in respect to the average grant, and in the fourth column the rank order of the average size of the Memorial average grant in respect to the other universities that competed in that committee.

The data in columns #3 and #4 provide a measure of Memorial's success in respect to the comparison group of universities within each research area in which Memorial has expertise. It then becomes possible to judge Memorial's relative success in the various research areas by ranking the 24 areas. For example, Industrial Engineering ranks second out of the eight universities that compete under this committee. This converts to a decimal rank of .25, which is the best rank achieved by any group at Memorial. Therefore, Industrial Engineering ranks first, in respect to this measure, among the 24 areas. Similarly, we can rank the areas in terms of the percentage in respect to the discipline average and produce a second internal ranking of Memorial's success in respect to the comparison group.

There are three committees directly related to the Department of Mathematics and Statistics³⁰. These are Pure and Applied Mathematics - A, Pure and Applied Mathematics - B and Statistical Sciences.

In terms of average grant size as a percent of discipline (column #3), Pure and Applied - B ranks third among the 24 Memorial research groups, Statistical Sciences ranks fifth among the 24 Memorial research groups, and Pure and Applied - A is tied for 19th with Computing & Information science among the 24 Memorial research groups³¹.

Table 7.1

²⁹Paul Chancey, personal communication.

³⁰Not all grant holders in the department apply to the three committees discussed. For example, Dr. D. Summers has a grant of \$34,600 from the Space and Astronomy Committee. Dr. Summers grant is essentially 100 per cent of the average for that committee, so that the poor showing for that committee is due entirely to a researcher in another unit.

³¹The highest percentage obtained by an Atlantic Canadian university in Pure and Applied Mathematics - A was that of Dalhousie which was 70 per cent.

Committee	Ave GSC	Ave MUN	#2/#1 %	Rank	# GSC	# MUN
Anal. & Phys. Chemistry	42.0	28.0	67	8 th of 9	296	6
Animal Biology	29.0	21.2	73	9 th of 9	229	2
Animal Physiology	36.4	32.9	90	7 th of 9	192	5
Cell Biology	34.9	26.2	75	8 th of 8	278	4
Civil Engineering	24.7	20.7	84	7 th of 8	498	12
Comm, Comp & Components	23.9	18.3	77	8 th of 9	313	6
Computing & Information Sci.	25.7	17.4	68	8 th of 9	551	10
Condensed Matter Physics	32.6	29.1	89	4 th of 5	207	4
Electromag. & Electr. Systems	26.1	20.8	80	9 th of 9	273	9
Environmental Earth Sciences	25.8	23.6	91	8 th of 9	333	8
Evolution & Ecology	30.9	23.0	74	6 th of 9	426	18
General Physics	32.7	29.3	90	4 th of 6	121	3
Industrial Engineering	22.0	22.7	103	2 nd of 8	232	3
Inorganic & Organic Chem.	48.7	39.3	81	5 th of 9	276	6
Interdisciplinary	24.6	24.7	100	4 th of 6	69	2
Mechanical Engineering	24.5	20.4	83	8 th of 9	512	10
Molec. & Develop. Genetics	40.2	26.6	66	9 th of 9	184	2
Plant Biology & Food Science	36.3	22.0	61	8 th of 9	294	2
Psychology	27.8	25.8	93	5 th of 9	356	9
Pure & Applied Maths - A	15.8	10.7	68	7 th of 9	296	7
Pure & Applied Maths - B	15.4	14.8	96	5 th of 9	221	2
Solid Earth Sciences	33.6	27.4	82	8 th of 9	278	12
Space & Astronomy	35.0	19.8	57	7 th of 8	150	2
Statistical Sciences	15.0	13.7	91	4 th of 8	247	4

As noted column #4 provides the rank of the average size of a grant obtained by a Memorial researcher in comparison to the other universities that competed under that committee. In respect to this measure, Statistical Sciences ranks second among the 24 Memorial research groups. Pure and Applied - B is tied for third with Inorganic and Organic Chemistry among the 24 Memorial research groups, and Pure and Applied - A is tied for eighth with Animal Physiology among the 24 Memorial research groups.

What is clear is that in terms of the universities that Memorial chooses for its comparison group, researchers in the Department of Mathematics and Statistics are among the most successful in the university when it comes to accessing NSERC funds. To the degree that the ability to extract funds from NSERC is an accurate proxy for excellence in research, the analysis presented shows the Department of Mathematics and Statistics to be one of the strong research units in the university. Certainly, mathematics and statistics, ought to be seen as a major areas of strength.

7.3. Costs

It is suggested in the guidelines that the best way to assess the cost effectiveness of a unit under review should be to compare it with similar units at other universities³². The authors of this report choose not to do that for three fundamental reasons.

First, there is a requirement that the comparison units be similar. It is the authors' belief that there are no similar units, for two reasons:

- Memorial is the sole university in the Province of Newfoundland and Labrador which confers added responsibilities beyond what would be the case for a department of mathematics and statistics in a university in the comparison group identified above, all of which are located in multi-university provinces;
- no other department of mathematics and statistics is known to have been the subject of Provincial and Senate inquiries into its instructional effectiveness.

Second, there is a specific principle set out in the framework document to the effect that *equitable resource allocation is an important means of achieving the University's goals*. Such a statement demands that appropriate internal comparative data be presented so that a judgment can be made as to whether this principle is being followed.

³²A7.3 contains a memo from the vice-president (academic) that came to the department on February 20, 2001. It contains enrolment and faculty numbers data for comparison purposes from other universities. Not a single one of the comparison group of universities is from Atlantic Canada. Therefore, these are not the universities we compete with for students, and to base a faculty complement policy on this type of data, seems completely inconsistent with the principles and goals so carefully articulated in the Framework document. As well, many of the universities listed have admission standards that would preclude the admission of students coming from the academic stream in high school, which means we are dealing with apples and oranges.

Third, because data in respect to Memorial comes from a single source, namely CIAP, it has a uniform quality, and all data in the same category satisfy the same operational definition. Thus, it is reasonable to make comparisons and draw conclusions within the limits of the data.

Copies of the *Academic Unit Profile 1998-99* were included as A1.3. Table 7.2 contains summary data for the 1998-1999 academic year. There is nothing particularly special about this year, other than it is the most recent; data in other years would appear similar. The specific variables presented are: Total Lecture Registrations; Total Undergraduate Lecture Sections³³; number of Regular Full-Time Faculty; number of Staff³⁴; Estimated Undergraduate Tuition Revenue (\$M); Net Expenditure (\$M); Total Expenditure per Lecture Registration (\$). This data is presented for all units in the Faculty of Science, the Faculty of Science as a whole, the Faculty of Arts and the university in total.

In terms of lecture registrations, the department teaches approximately 25 per cent of those in the Faculty of Science, or eight per cent of the university total. In terms of undergraduate lecture sections, the percentages are 28 per cent of those in the Faculty of Science, and five per cent of the university total. It has already been noted that approximately 80 per cent of the registrations are service related and that this percentage is consistent with the percentage at other Group I institutions in North America.

The department has 18 per cent of the Faculty of Science regular full-time faculty and six per cent of the University's faculty; the department has four per cent of the Faculty of Science staff and two per cent of the university staff.

For net expenditure, the percentages are 13 per cent and five per cent, respectively.

The last column gives the expenditure per lecture registration. The department expends \$366, which is fifth lowest among more than 30 units for which there is data given in the *Academic Unit Profile 1998-1999*. The figure for the Faculty of Science as a whole is \$725, for the Faculty of Arts it is \$499 and for the university as a whole, it is \$639³⁵.

Although in absolute terms, the Department of Mathematics and Statistics has one of the larger budgets in the Faculty of Science, by the measures presented it is arguably one of the most cost effective in the entire university in terms of performing its teaching function. The central question is whether this apparent efficiency is real or simply evidence of neglect? That question will be addressed in the next section.

³³The number for the department is reduced to exclude sections taught at the MLC.

³⁴Two staff positions in Computer Science have been transferred to the Department of Mathematics and Statistics to account for the cooperative computer support agreement between the two departments.

³⁵Implementation of the vision described could be achieved with an expenditure on the order of \$550 per lecture registration, that is, a bit more than the average for Arts, and substantially less than either the average for Science or the university as a whole.

Table 7.2

1998-1999 FACULTY OF SCIENCE							
Department	Tot Lec Reg	Tot UG Secs	Reg F-T	Staff	Est UGT M\$	Net Exp M\$	TEPLR \$
Biochemistry	1,712	30	15	14	0.58	1.5	917
Biology	5,211	73	32	36	1.7	3.5	681
Chemistry	3,139	54	23	29	1.0	3.1	1,000
Computer Science	2,805	71	18	13	0.92	1.8	651
Earth Sciences	1,409	43	23	19	0.47	2.2	1,548
Math & Stats	8,207	167	37	10	2.7	3.0	366
Physics	2,175	51	16	17	0.71	1.8	838
Psychology	7,958	94	31	8	2.6	2.7	344
OSC?	0	0	10	22		1.4	---
Science Other	396	3	3	11	0.1	1.6	6,714
Science Total	33,012	599	208	179	10.9	22.7	725
Arts Total	34,480	1,042	187	61	11.2	16.3	499
U Total	101,588	2,688	580	407	33.5	60.6	639

8. EQUITY AND RESOURCE ISSUES

Section 1 of this document, began with a 15 year history of reductions in resources that culminated in two external reports criticizing teaching practices in the department that produced high failure rates. Documentation was also included establishing that these concerns for instructional quality continue to exist today. As a response, the section concluded with a vision for the future that combined a commitment to quality undergraduate instruction with an equivalent commitment to research excellence. This vision would require an investment in mathematics and statistics that is substantial. The questions that have to be addressed is whether such an investment is an effective use of university funds, and is consistent with the principle of equity in the distribution of resources?

On the positive side, the remainder of the report documents that the department had made excellent use of the resources that the university has made available. In briefest summary, it is one of the more effective departments in competing for research funds, and all new hires have been successful in NSERC competitions. As departments of mathematics and statistics in Group I-III universities go, it regularly produces a large number of majors. To the degree that resources have been made available, the department is aggressively expanding its graduate program. It has also invested in instructional quality and used the graduate program as a contributor to the undergraduate program in a manner that benefits both graduate students and teaching quality.

That said, Section 2 of this document establishes that the department's faculty resources are about to shrink precipitously, to the point where we will be completely unable to deliver programs³⁶. Section 4 documents pressures from the dean's office to reverse investments in instructional quality by raising class size, taking faculty out of labs and teaching an ever larger percentage of the department's courses with sessional instructors. Section 6 documents the need for additional support staff, significant additional space, and a past failure to properly implement the terms of the *Collective Agreement* in respect to workload. Section 7 presents data on effectiveness and evidence of substantial differences in respect to resource allocations between departments. The key question is whether the differences are fair and equitable?

8.1. Analysis of Faculty of Science Budget

Table 8.1 contains a summary of budget information for the Faculty of Science for the line academic departments and the Ocean Sciences Centre (OSC) from the last budget year³⁷. The variables in Table 8.1 are: total academic salaries; total administrative salaries; total operating; capital; and,

³⁶A8.1 details the number of statisticians necessary to offer all instruction with regular full-time faculty.

³⁷The information presented was circulated to all heads as part of the budget process. The documents from which the data is extracted are included as A8.1.

Table 8.1

1998-1999 Actual Expenditures (thousands \$)						
Department	Academic Salary	Admin Salary	Operating	Capital	Mat/Sup	Stud Asst
Biochemistry	996	389	147	35	84	28
Biology	2,021	1,040	522	11	227	189
Chemistry	1,757	968	406	3	162	169
Comp Science	1,154	488	133	56	60	46
Earth Sciences	1,492	528	147	0	52	37
Math & Stats	2,566	257	172	6	59	67
Physics	1,074	582	137	27	65	37
Psychology	2,310	233	176	11	65	73
OSC	661	547	222	3	138	

materials/supplies and student assistants, which are line-items contributing to operating that typically comprise 75-80 per cent of the total for operating in any year³⁸.

A principal argument for differences in the budgets of the various departments, and in particular, the values of Total Expenditure per Lecture Registration (see Table 7.2), is the differing intrinsic costs of instruction. For example, it is asserted that a lecture section of biochemistry, biology, etc., with its attached lab costs more than a lecture section of statistics with its attached lab. To the degree that this argument is valid, it should be understandable in terms of an analysis of the budget. The analysis that follows excludes the OSC which functions as a research institute. As such, it has no students and hence, no instructional costs. However, this exclusion is *de facto* erroneous because at least some faculty from the OSC teach courses for departments, and many direct graduate students even though all entries in the *Academic Unit Profile 1998-1999*, associated with teaching, are zero for the OSC. Without more information, OSC resources expended on teaching activities cannot properly be allocated.

Table 8.2 recalculates the Expenditure per Lecture Registration for each of the categories in Table 8.1 for the academic departments.

The entries in the Materials/Supplies column in Table 8.2 range from a high of \$52 to a low of \$7. Inspection of which departments fall at the high end, and which at the low, appear to reflect the rationale that lab sciences requiring chemicals are, indeed, more expensive than other sciences. However, the gross amount of the difference, \$45, will not explain a total difference (see Table 7.2) of more than \$1,000 between Psychology and Mathematics and Statistics, on the one hand, and Earth Sciences, on the other.

Operating. Consider the data under operating. Here the range is from \$131 to \$21. If one excludes student assistant costs, which are salary, the range is from \$79-\$13, and for five of the eight departments, Materials/Supplies comprises between 66-70 per cent of total operating. The exceptions are Earth Sciences at 47 per cent, Mathematics and Statistics at 54 per cent and Psychology at 61 per cent.

The differences in operating, even including capital, cannot explain the differences in per registration expenditure that turned up in Table 7.2. Since all remaining categories have to do with salaries, and the total range on per registration salary expenditures is \$1,469 to \$327, we are led to the first major conclusion:

- the major differences between departments that are observed in the value of the Total Expenditure per Lecture Registration variable result from salary differences.

³⁸The data presented in all cases appears representative in the sense that the value given reasonably reflects the value for the preceding year and the request for the successive year; an exception is the value for student assistants for Biochemistry which is anomalously low. It should be noted that the value for student assistants is the sum of the items in line 200 and 6,100, as this reflects most recent budget practice.

Table 8.2

	Department	Acad Salary	Admin Salary	Operating	Capital	Mat/Sup	Stud Asst
11.7	Biochemistry	586	229	86	21	49	16
15.2	Biology	389	200	100	2	44	36
13.1	Chemistry	567	312	131	1	52	55
12.8	Comp Science	412	174	48	20	21	16
11.4	Earth Sciences	1,066	377	105	0	37	26
18.2	Math & Stats	313	31	21	1	7	8
12.2	Physics	488	265	62	12	30	17
8.0	Psychology	289	29	22	1	8	9

This observation is certainly equally true across the remainder of the university, and likely is not a surprise to anyone who has carefully studied Memorial's budget data.

Salaries. The next question is whether the differences in salary expenditure across departments can be justified by differences in instructional costs?

The budget process requires each unit to calculate something called a *teaching task*, with the idea being that one teaching task is equivalent to a single three-hour lecture section³⁹. In order to go forward, a teaching task calculation is performed against the data available in the *Academic Unit Profile 1998-1999*⁴⁰. Table 8.3 contains the resulting calculated teaching tasks and related data.

The entries in the Teaching Task columns in Table 8.3 are derived in the following manner. The entry under **Lecture** is the sum of the three entries for LEC in the *Academic Unit Profile 1998-1999* for the department shown⁴¹. The entry under **Lab** is .5 times the total of the two entries for LAB⁴². The number under **Grad Sup** is .75 times the number of full-time graduate students shown in the *Academic Unit Profile 1998-1999*⁴³. While the actual calculation of teaching tasks presented may differ from actual computations carried out by the various heads, these calculations are uniform across departments and therefore permit at least first order comparisons.

The fourth column (**Staff-9**) in Table 8.3 contains the number of departmental staff reduced by nine. The subtraction of nine positions is performed under the assumption that all units require certain staffing levels, for example, two faculty support secretaries, a head's secretary, an administrative assistant, computer support personnel, and so forth, with the exact number varying

³⁹Quite clearly there is a relationship between three-hour lecture section equivalents discussed in Section 6.7 and the number of *teaching tasks* calculated here. The number calculated below does not account for sections involving a fourth hour, which makes all calculations below conservative in respect to the department under study.

⁴⁰We know that there are certain inconsistencies in the data, for example, some units offer sections for both graduate and undergraduate credit, and these are counted twice by CIAP. Sorting this and other complexities out would require a more extensive analysis.

⁴¹An implicit assumption is that the number of lecture sections offered by a unit is appropriate. It might be that program streamlining by a department could reduce this number for the unit.

⁴²During the budget process, counting a three-hour lab as half a teaching task for a faculty member who was solely responsible for the lab with no other support, was an agreed upon means of doing the calculation. It is accepted that in order to completely rationalize this calculation between units, it would be important to know exactly how each unit did the calculations. It is to be noted that on several occasions heads suggested that we carefully go through all the data, so all would understand the facts for all units, but that all such proposals have been refused by the current dean.

⁴³This computation of the teaching tasks associated with the supervision of graduate students was used for budget purposes in the last budget year with certain caps that could only lower the figure given. Thus, the value is likely an over-estimate.

Table 8.3

Department	Teaching Tasks			Staff-9	FTT	RFT-1	4×(RFT-1)-FTT	Surplus Staff	TES
	Lecture	Lab	Grad Sup						
Biochemistry	34	17	8.25	5	42.25	14	13.5	3	5
Biology	91	80	48	27	139	31	(15)	20	6
Chemistry	72	43.5	21.75	20	93.75	22	(5.75)	16	6
Comp Science	81	16.5	15	4	96	17	(28)	2	(6)
Earth Sciences	53	23.5	22.5	10	75.5	22	12.5	8	7
Math & Stats	170	48	10.5	1	216.5	36	(72.5)	0	(18)
Physics	59	19.5	10.5	8	69.5	15	(2.5)	6	2
Psychology	102	25.5	19.5	-1	147	30	(27)	-1	(7)
Total as (RFT)							-31		-5

from unit to unit⁴⁴. It is assumed that within this residual, that there will be laboratory instructors (LIs), and that to the degree possible, all labs will be covered from this residual with each LI being responsible for six lab teaching tasks per semester of hire⁴⁵.

Column five (**FTT**) contains the residual teaching tasks that must be covered by faculty after subtracting out the lab tasks that can be covered with available staff. Note that this number has to include all tasks associated with lectures and supervision, because these tasks cannot be performed by staff.

Column six (**RFT-1**) contains the number of regular full-time faculty less one. The reduction is to account for the fact that every unit has to use some faculty time for administrative purposes.

Column seven (**4x(RFT-1) - FTT**) contains the net surplus (deficit) number of tasks that could be covered if all faculty in the unit performed four tasks, which is the teaching load specified in the *Collective Agreement* for the Faculty of Science. Division of the numbers in this column by four will convert tasks into faculty positions.

Column eight (**Surplus Staff**) contains the surplus number of staff that are left after the number of staff required to cover all laboratories has been subtracted assuming each LI covers 12 lab tasks on an annual basis⁴⁶. Note that in all of this, the use of graduate students for teaching support has not been discussed. Since individual departments expend as much as \$55 under **Stud Asst**, it leads to the belief that the estimated surplus is conservative⁴⁷.

Column nine (**TES**) converts the data in the two previous columns into units of Regular Full-Time Faculty by dividing the entry on column seven by four and adding it to half the entry in column eight, under the assumption that two staff members would convert to one faculty member⁴⁸. The heading stands for **total estimated surplus**.

⁴⁴Staff numbers should also be reduced to account for functions that serve university wide purposes, e.g., a staff member hired in the Department of Physics to maintain the liquid nitrogen facility which serves the university community as a whole should be removed, but then so should that portion of the budget. This analysis does not account for a component that depends on faculty complement.

⁴⁵The Department of Mathematics and Statistics has one LI hired on an eight-month contract and that individual is responsible for the equivalent of six lab tasks in each semester. This is the basis for the calculation. The number calculated is consistent with what is expected in the Department of Computer Science. It may be that six per term is too many in some units, but surely there is a number that is justifiable for each unit.

⁴⁶Quite clearly there are staff that indirectly support teaching, e.g., the stores supervisor in Chemistry. The data are insufficient to account for these activities.

⁴⁷The comments of W. Barker in his report on feasibility of graduate student teaching should be reviewed here, particularly items 8(b) and 15 (see A4.10).

⁴⁸In making this conversion, the estimate is in terms of salary equivalents.

It is now possible to draw some conclusions. First, in column seven, observe that only two departments, Biochemistry and Earth Sciences, are able to cover all teaching tasks with existing faculty complement⁴⁹. Both are small and lack a large entry-level registration base that would bring down costs. However, both also have faculty surpluses in excess of three full-time faculty and both show additional staff surpluses⁵⁰, which leads to the conclusion, that a significant factor in the high costs of operation has to do with salary factors that cannot, under this analysis, be associated with instruction.

All the remaining entries in column seven are negative. However, three of the remaining departments, Biology, Chemistry and Physics, have substantial numbers of apparently surplus staff that could compensate for the negative value in column seven. That compensation could occur, is shown by the values in column nine (TES) for these three departments. The positive values show that there is a surplus which is large in two cases, on the order of seven positions, and approximately neutral in the third case. Again, the analysis shows that a substantial portion of the higher costs are not accounted for on the basis of instruction.

The remaining three departments, Computer Science, Mathematics and Statistics and Psychology all show deficits in their respective abilities to meet their instructional requirements. The estimated short-falls are: six, 18 and seven faculty positions, respectively.

At this point there are two possible conclusions. First, that departments like Biology and Chemistry genuinely do not have sufficient resources to cover their needs, whence it appears to follow that the same would have to be true for departments like Computer Science, Mathematics and Statistics, and Psychology. Under this conclusion, the Faculty of Science has a total deficit of 31 full-time faculty. The alternate conclusion is that the departments like Biology, etc., have surplus resources in respect to instruction, and that while departments like Computer Science have needs, these may be less than estimated. Under this conclusion, the Faculty of Science is approximately at break even in terms of having sufficient faculty to deliver its teaching. If the former is true, then the Faculty of Science as a whole is substantially underfunded, which is certainly the view internal to the Faculty. If the latter is true, then the problems could be solved by a re-allocation of resources within the Faculty of Science, and this is the view that has been consistently expressed to the current head by members of the senior administration, most notably the present and past vice-presidents (academic).

Short-fall. The suggested short-fall in the Department of Mathematics and Statistics of 18 regular full-time faculty appears startling. Quite clearly, the question of whether it can be justified begs for an answer.

⁴⁹Here is the key place where the role of OSC faculty in teaching seriously could affect the value for some departments, particularly Biology, by reducing the apparent deficit.

⁵⁰It is recognized that some surplus staff may be necessary to support instruction, for example, significant numbers of technical staff are required to maintain the entirety of the computing infrastructure in the Department of Computer Science, and this infrastructure is essential to the teaching mission of the department. Similarly, some additional numbers of staff may be necessary in other departments, but many of the numbers are simply not plausible to the authors of this report.

A8.2 contains the course offering plan in statistics that has been in operation for the past several years. It includes sufficient entry-level sections to cover demand, and the bare minimum of advanced courses to satisfy the program requirements of students doing majors and honours. In terms of lecture sections and labs, the totals for the year are: entry-level, 22 lecture and 50 labs; advanced, 13 lecture and three labs; graduate, five lecture⁵¹. This translates into a required faculty complement of 13.5 regular full-time faculty, with no accounting for graduate student supervision, or the fact that faculty are entitled to sabbatical leave. At present, there are six in the statistics group, so that at least six additional positions can be justified by demands for instruction in statistics⁵².

A legitimate question is how the department managed to cover its statistics courses in the present year? The answer is that two individuals graduated from the MAS program last year and agreed to take eight-month contractual positions this year, teaching three courses per term. Were it not for these individuals, together with sections covered by graduate students and a small number of sessionals, a substantial number of entry-level statistics courses would not have been covered. Since both of the individuals on contract will take up positions with Statistics Canada in June, and requests to hire statisticians have been refused, short of unexpected good fortune in the form of qualified instructors appearing from nowhere, the department will not cover its statistics courses in the fall⁵³.

Given the retirement and resignation situation on the math side, with three additional positions being lost, the same situation of being unable to cover courses could easily hold true for entry-level instruction in mathematics⁵⁴.

The authors believe that the data presented above establish that the short-fall is real and well-approximated by 18 over the base, which was 37 regular full-time faculty. That said, the vision calls for a smaller number, 50, with the rise occurring over a period of years so that an optimal mix of faculty and graduate students can be achieved⁵⁵.

8.2 Budget Negotiations

Budget considerations during the past several years have occurred under a scenario of declining budgets, and a demand that departments become more efficient. Specifically, it is argued by the dean that the principal mode for achieving saving is through more efficient provision of instruction.

⁵¹The lab sections in this data are 1.5 hours in duration.

⁵²Inspection of the faculty record in A2.2 shows that the department had 11 statisticians in 1989.

⁵³A2.3 contains a memo to the dean of science detailing this and the need to hire in a timely way.

⁵⁴The department's budget submission for 2001-02, which fairly and equitably follows the *Collective Agreement* will show 225 teaching tasks of which 125 can be covered by regular full-time faculty.

⁵⁵Again, it should be emphasized that these calculations have not accounted for sabbaticals, or such things as fourth hour in determining teaching tasks.

There are two main tools that have been proposed to deal with Faculty of Science budget short-falls, namely, larger entry-level classes and fewer lab periods. Indeed, both have been implemented in various departments in past years.

Let's examine the effectiveness of these tools for achieving the purpose in view of the budget analysis above. First of all, saving on operating cannot address a Faculty of Science deficit of any substantial size because operating is a small part of the total, five to seven per cent for five departments and only 13-14 per cent for the two departments in which operating is largest.

It follows that the only way to achieve savings is by shedding positions. Thus, for example, if the only expenditure category affected is operating, reducing the number of labs in entry-level courses cannot realize significant savings.

Now consider increasing section sizes as a means to achieve savings. Since the university has signed contracts with MUNFA that restrict its ability to effect layoffs other than by attrition, raising class sizes can only have an effect in a situation of under-staffing. In a situation where there are already more faculty than is needed to cover a department's teaching tasks, raising class-size can only have the effect of increasing the available time for research⁵⁶. It has no effect on expenditures, because salaries cannot be reduced for administrative reasons, or so it would seem from the *Collective Agreement*

To conclude this discussion, consider how raising class-size could have a positive effect on budget. First, for lay-offs to be avoided, it must be the case that permanent staff are not in place. It is evident that there are only three departments for which this is the case, namely, the three having insufficient faculty to cover their teaching requirements. Of these, obviously, the Department of Mathematics and Statistics offers the greatest potential savings. However, raising class size with no cost can only occur if the requirement in the *Collective Agreement* to fairly account for class size in the computations of teaching tasks is entirely ignored. In short, there is serious conflict between the *Collective Agreement* and desires for efficiency.

8.3. University Goals

Section 1 of this document began by articulating the goals and principles set out in the *Framework* document. Among these was the following:

Memorial will continue to provide strong academic support to undergraduate students and to support extensive involvement of regular faculty in undergraduate classrooms and laboratories, but in response to the needs of a changing economy it will also expand research and graduate teaching as high priorities. (p. 1)

⁵⁶It is obvious that additional hiring in such departments can only exacerbate the budget problems.

Section 1 also set out a vision for the department that, in the opinion of the authors, addresses this goal in a cost effective manner.

A question that the review committee must answer in its report is whether the vision articulated does indeed address the goal?

A fundamental principle also contained in the *Framework* document is:

Equitable resource allocation is an important means of achieving the university's goals, (p. 4)

A second question that must be addressed is whether resources have been and are being allocated in an equitable manner that would permit the department to achieve its goals? If the answer is yes, then, in the view of the authors, it would require substantial analysis and additional data to explain how the analysis presented above is flawed. In any case, the Report must certainly address this question.

9. CONCLUSION

Previous sections have reviewed the current state of the Department of Mathematics and Statistics. On the positive side, it has been shown that the department has taken steps to:

- improve the quality of undergraduate instruction;
- expand its graduate program;
- become recognized as an outstanding research department.

In addition, the department has adopted a vision for the future that would provide excellent undergraduate instruction in a cost effective manner by using its graduate program as a material contributor to its undergraduate program. All of these are consistent with the goals and principles set out in the framework document, but significant investment on the part of the university is required

On the negative side, documentation has been provided that show that

- the quality of undergraduate instruction in the department remains a concern in the wider university community;
- that the department has been unable to convince those responsible for providing resources of its needs in respect to faculty and space;
- that in respect to the priorities of the Faculty of Science, the Department of Mathematics and Statistics comes last, if at all;
- that in respect to the research priorities of the university, mathematics and statistics comes last, if at all.

If the arguments and analysis presented are valid, it is hard to see how the department could ever achieve equity within the Faculty of Science. The reason for this is simple. Distribution of the Faculty of Science budget is the responsibility of the dean, and past and present vice-presidents (academic) have consistently taken the position that they cannot tell the dean how to allocate monies. Therefore, given the internal position within the Faculty of Science to the effect that most departments are seriously underfunded, so much so that Biochemistry, Biology, Chemistry, Physics and Psychology would all take precedence over Computer Science and Mathematics and Statistics in the current round of allocation of bridging positions, it seems a reasonable conclusion that fairness and equity could not occur in this context. This leads directly to the conclusion that moving these two departments out of the Faculty of Science and forming a School of Information and Mathematical Sciences would be fully justified.

Memorial University aspires to greatness. It remains to be seen whether it can achieve greatness without supporting excellence in a core discipline like mathematics. In going forward, the university might do well to emulate the resolution of the National Science Foundation to “triple its commitment to mathematics over the coming years to reverse the subject’s decline and meet the growing needs of other disciplines.”⁵⁷

⁵⁷Rita Colwell, Director of the National Science Foundation, quoted in *Nature* (see A9.1).