Career Opportunities in Mathematics and Statistics

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Students with ability in mathematics are avoiding the subject once they leave high school, the main reason for this being that they do not recognize the wide variety of careers that training in mathematics and statistics can lead to.

The Mathematics Department at the University of Alberta is eager to publicize the opportunities our programs offer. The following sections on "Careers in Mathematics" and "Careers in Statistics" were prepared for the University Student Counselling Service. If you would like a representative of our Department to speak to your students or staff on career opportunities and the programs we offer, please call Myrna Janzen at 432-3396.

Careers in Mathematics

Description of Subject Field

Many people do not realize how widely mathematics is used and, as a result, ignore mathematics courses in their training. Later they find themselves severely handicapped in their careers.

Mathematics is extremely important in modern society. It is as useful as ever in engineering and physics, and has become indispensable in economics, business, biology, medicine and many other fields. For example, law schools find that education in mathematics is good training for their students. Each year the University of Alberta Mathematics Department must accommodate more students whose programs require more mathematics than was required in the past.

Unfortunately, there seems to be an educational and intellectual barrier to learning mathematics after being away from it (very much like the barrier that makes it harder for an adult to learn a foreign language than it is for a child). As a result, people who are trained in mathematics and are knowledgeable in another field are in constant demand. In addition, the number of students with above-average ability in mathematics is not large. Therefore, persons with advanced training in mathematics find themselves even more in demand.

Mathematics can be regarded in three ways:

1. It is a discipline which insists on careful and logical thinking. A mathematics major develops mental habits which are extremely important for success in many fields. This is one reason why students trained in mathematics

do so well in areas far removed from it, like law, for instance.

2. Mathematics is a tool which can be used to recognize and solve problems. Most students are attracted to the subject (or are required to take it) because it has been applied so successfully in so many different areas.
3. Mathematics is an art form as beautiful and creative as painting, chess, or poetry. New forms of mathematics are constantly being created. Often it is only later that the newly invented forms are found to be useful in solving significant problems in the real world.

The University of Alberta offers several different, flexible programs in mathematics designed to appeal to a wide range of students.

Preparation (High School and Other)

The more mathematics you take in high school, the better. To enter any of these programs you must complete Mathematics 30, and you would be wise to take Mathematics 31 also. You should check the requirements for admission to the Faculty of Science in the current University Calendar.

The Department also offers a B.A. degree in the Faculty of Arts. Details on admission requirements to this program can be obtained from the Faculty of Arts section of the Calendar.

University Instruction

A *Specialization* degree in mathematics takes four years and includes at least eight courses in mathematics and statistics. You may choose twelve other courses to satisfy your interests and faculty requirements.

This is the degree program that provides flexibility for the student who is interested in mathematics and has a strong interest in another field as well. It is an excellent program for the student who wants to apply mathematics in business, economics, computing science, statistics, engineering or education, or who wants to attend graduate school in any of these subjects.

The Department also offers a specialization program with concentration in actuarial science designed to train actuaries and to prepare students for graduate work in Faculties of Commerce.

The *Honors* degree in mathematics is an intellectually-rewarding program that usually contains at least ten honors-level courses in mathematics or statistics. These courses are more difficult than those normally taken by non-honors students.

Although it requires more mathematics than the specialization program, this program is still flexible enough for the student to design a program to fit his or her particular career interest. Past honors graduates have been very successful in a wide range of careers. They include professors, doctors, lawyers, economists, computing scientists, statisticians and businessmen.

The three-year B.Sc. degree with concentration in mathematics can be used to obtain a broad liberal arts education, or training for a career in teaching, or it can be used for further studies in another area. Many students who originally enter this program eventually change to the specialization or honors program as they learn how useful it is to take more basic courses in mathematics and statistics.

Career Opportunities

Training in mathematics is useful for a wide variety of careers. Here are some examples:

TEACHING (Secondary)

No matter what your career interest, from agriculture to pharmacy, mathematics is important. This means that there will always be a demand for people with ability in mathematics to teach the subject.

Since most secondary pupils will be learning mathematics for use as a tool, students interested in education can enhance their opportunities for a teaching career by choosing options in a degree program that cover areas in which mathematics is applied. Students in mathematics programs may choose up to four options in the Education Faculty. A student can obtain a teaching certificate by studying in the Education Faculty after receiving a degree in mathematics.

ACTUARIAL PROFESSION

Actuaries are specialists at designing pension and insurance plans. They are employed by governments, labor unions, corporations and other large institutions.

Before becoming an actuary, a person must pass exams set by the Society of Actuaries. The Department offers mathematics of finance courses specially designed to prepare students for the actuarial exams. Since actuaries must be well trained in mathematics and mathematics of finance, they are also in demand for general executive positions.

UNIVERSITY AND COLLEGE TEACHING

A university teaching position usually requires a research-oriented Ph.D., while college teaching requires a teaching-oriented Ph.D. or a strong M.Sc. The proper training for teaching at these levels is a degree in mathematics followed by graduate study in the desired specialty, such as mathematics, statistics, management science, computing science, economics, operations research, physics or engineering.

It is difficult to predict now what job opportunities will be open in college or university teaching eight or more years from now. Currently, mathematicians with Ph.D. degrees in computing science, operations research, or statistics are in very short supply. Those trained in management science, economics, or numerical analysis also have plenty of job opportunities today. A few years ago, mathematicians with research interests in geometry or algebra were in demand.

INDUSTRY

Mathematicians working in industry are either employed in a general executive capacity (hired because of their ability to think logically) or are actually applying what they know to solve problems in such areas as research, design, or marketing. Students interested in an industrial career should concentrate their options in economics and other business-related courses, in statistics and computing science, or in some area of physics and engineering.

GOVERNMENT

Most mathematicians employed by the government are specialists in statistics (especially with computing) or have concentrated their options in economics and management science. There are also opportunities for applied mathematicians trained in physics and engineering with such government organizations as the National Research Council, Alberta Energy Corporation, and the Defense Research Board.

LAW

You may be surprised to find a profession such as this under career opportunities in mathematics. But an actuary who also has a law degree, for example, is in a powerful position when it comes to employment. A person who is able to combine training in mathematics, statistics, and computing science with a law degree is in a position to help solve the new legal problems which arise from our sophisticated technological age.

For more detailed information on programs available in the Mathematics Department, please write to:

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Careers in Statistics

Description of Subject Field

The best way to define statistics is to consider what the statistician does and why.

Originally, statisticians studied characteristics of people in a population, classifying them according to such criteria as age, marital status, and sex. They then summarized these data in the form of tables, charts, and graphs in order to make comparisons. The result was a general *description* of the population.

As statistics developed, many of the words used in population studies came to be used in a much wider context. For example, a *population* can be any collection of objects or ideas about which information is required. Today's statistician may study a population of shoes, ships, or of sealing waxes; cabbages, kings, or even of political opinions.

In a great many experiments, the results are influenced by extraneous factors which cannot be completely eliminated or controlled. The effects of these factors are usually of least importance in the physical sciences where rigid control can be maintained under laboratory conditions. They are of greater importance in the biological sciences, and of greatest importance in the social and behavioral sciences where it is often impossible to impose any control at all. The statistician is concerned with the haphazard or *random* variations resulting from such factors.

EXAMPLES:

- Four observations were made on the electron charge. The results in coulombs were 1.60203×10^{-19}, 1.60206×10^{-19}, 1.60209×10^{-19}, 1.60207×10^{-19}.
- One hundred grains of wheat were planted in each of four plots of earth. The numbers germinating were found to be 76, 82, 79, 80.
- Four students were given an intelligence test. Their I.Q.s were found to be 84, 143, 112, 106.

You will notice in the first example that there was relatively little variability in the measurements of electron charge.

In the second example, where less rigid control was possible, the variability is much larger and you might think about possible reasons for the variation. These could include variations in soil fertility, in light and shade, in moisture or in the genetic material of the wheat grains.

The third example, where virtually no control is possible, shows the greatest variability. Sources of

variation here could include difference in sex, genetic background, cultural and physical environment, or even in what the students had for breakfast.

In studying such "chance phenomena," the statistician tries to design experiments to eliminate, minimize, or balance the effects of the extraneous factors. The results of the experiments are used to make inferences about the unknown situation under study.

A report on work done by a statistician would typically include an estimate of the reliability of the conclusions. For example, you might estimate that on the average, 80 percent of a certain type of wheat grain germinate and that the true (unknown) germination rate is almost certainly between 78 and 82 percent.

No summary of modern statistics would be complete without mention of the central role played by the Mathematical Theory of Probability. Without it, statistics would not have developed beyond the descriptive stage. Today's statistician wants to be able to make statements like "I am 95 percent confident that the average height of Slobovians is between 65 and 67 inches." Here's where the Probability Theory comes into play. With it, the statistician can assess the reliability of experimental results.

Statistical procedures have been devised even for measuring the risks of making the wrong conclusions!

University Instruction in Subject Field

Before World War II, most statisticians entered the field because they were interested in solving problems which arose in other areas they were experts in.

Noted examples are the careers of statisticians R.A. Fisher, who started as a schoolmaster with an interest in genetics, H. Hotelling, who began his career as an economist, and J. Tukey, who was originally a mathematician.

In recent years, statistics has developed rapidly as a discipline in its own right.

At the University of Alberta, statisticians find their home in the Department of Mathematics. Applied statistics is also taught by a number of other departments and faculties including agriculture, business, computing science, education, engineering and psychology.

Degree programs offered by the Department of Mathematics include a four-year honors B.Sc. program in mathematical statistics and a four-year B.Sc. program with specialization in statistics, as well as graduate degrees at the master's and doctoral levels.

The honors program stresses the mathematical and theoretical foundations of statistics and is designed mainly for students going into academic or research careers.

The specialization program, while giving a sound theoretical foundation, is directed toward students who would apply statistical methods in various other fields. This program provides students with a wide range of career choices.

To enter either the honors or specialization programs, you must take Physics 30 or Mathematics 31 in high school. You can check other requirements for admission to the Faculty of Science in the current University Calendar.

Career Opportunities

Statistics can be applied in such a wide range of fields that it is impossible to list them all. The following broad categories may offer some guidance:

GOVERNMENT

Since the days of Imperial Rome and probably even before, governments have found it necessary to collect statistical data on population, agricultural production, and trade for the purposes of levying taxes, conscripting armies, ensuring food supply, organizing elections and enforcing laws. With the increasing complexity of government planning, data piles up at an accelerated pace. In this country, Statistics Canada devotes itself exclusively to collecting, summarizing, and interpreting data on an ever increasing range of topics. Just glance at the Canada Year Book and you will be amazed at the great scope of these activities - and that's just on the national level. Provincial and municipal governments also collect, summarize, and publish statistics.

Population and technology are expanding so rapidly that governments must note trends as early as possible so that they can plan efficiently for the future. For example, knowledge of the 1979 birth rate is essential to the planner of elementary educational facilities for 1985, to the planner of secondary school facilities for 1993, and to the university planners for 1997.

In the past, governments have tried to obtain *complete* data on each individual item of interest. Thus, in the federal census, the aim is to obtain information on *every* individual in the population.

In other areas, the enormous cost of such a study is prohibitive. So statisticians must resort to statistical inference from appropriate samples in order to arrive at conclusions about a population. This introduces problems of sampling. How should a sample be selected so that it is representative of the population? How large should it be so that the conclusions have a prescribed reliability? These and other sampling problems are the subject of serious study by statisticians.

As well as the economic advantage of using statistical inference from samples, there is often an important saving in time. This was illustrated during World War II when Allied statisticians had to estimate German industrial output. They based their estimates on studies of the serial numbers of captured German equipment. After the war, detailed study showed that these estimates were as accurate as those made by the Germans themselves. Furthermore, the Allied estimates were available considerably sooner since they were based on sampling methods, while the Germans waited for complete coverage.

BUSINESS

Statistical methods find almost unlimited scope for application in business and finance. Many corporations employ statisticians to study consumer preference, inventory analysis, and quality control and to predict business cycles and trends.

For example, a telephone company needed to determine the value of its capital equipment such as poles, cables, batteries, tools and buildings. It had lists of these things and knew their original and replacement costs. But what percentage of their useful life still remained? This was costly to estimate because many items were in remote areas or inaccessible positions or because the evaluation required highly-paid

experts, or dismantling equipment and interrupting service. Furthermore, the number of items was very large.

Instead of examining every piece of equipment, which would have been prohibitively costly, the company chose a relatively small sample of each type of equipment according to statistical principles. The average condition of each kind of item was then estimated from the samples and an allowance was made for possible errors due to sampling. The results were as useful as if a full examination had been made.

SCIENCE

Much of modern statistical theory grew out of attempts to solve certain problems in experimental agriculture. Plant and animal breeding experiments, genetic studies, comparative studies on fertilizers, experiments on animal nutrition and countless other studies have led to highly refined and efficient techniques for designing and analyzing experiments.

In the health sciences, researchers use statistical methods in their search for the causes of disease and in the evaluation of new forms of therapy. The extensive statistics on Salk Polio Vaccine and on smoking and lung cancer are well-known examples. Stochastic (random) models have been designed to describe such phenomena as epidemics, the reproduction of elementary organisms, and the movements of spermatozoa. Statistical methods are regularly used in dose-response studies of drugs.

In the social and behavioral sciences too, the range of application of statistics is very wide. Statistical models have been devised to describe such things as the learning behavior of rats, the formation of cliques in human societies, and dominance behavior in primates. In the fields of intelligence, personality, and aptitude testing, statistical analysis has long played an important role.

These examples show only a few of the applications of statistical methods in science.

The Employment of Statisticians

Currently there is a shortage of qualified statisticians in North America. Statisticians are well aware of the demand for their services and many set themselves up in private practice as consultants to government and industry. In this way, a hard-working statistician in a large centre can easily earn an income of $100,000 a year or more.

In the United States, about 40 percent of all statisticians are employed in business or industry, about 30 percent in government, and about 20 percent in academic posts or research centres and the remainder in miscellaneous positions. Comparable figures are not available for Canada, but almost certainly the number of statisticians in government or in academic posts exceeds the number in business and industry. Thus, statisticians will find even more career opportunities in the world of commerce in Canada.

For more detailed information on programs available in statistics, please write to:

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