Social issues and Statistics Canada resources in the mathematics classroom

Geoffrey Roulet

After basic arithmetic, which we all use for our regular financial transactions, statistics is the branch of mathematics with which we have most contact.

This is not to claim that we are all practising statisticians, but daily every adult receives political, commercial, financial, and ethical messages that are connected to statistical data. This morning the newspaper presented me with the headline, "Canada not keeping pledge to halve hunger" (Orwen, 2002, June 10, p. A17). On what is this claim based? How many people in Canada do not have sufficient food? What is the definition of "hunger" that the author is using? And what are the causes of this situation? There is a strong need for statistically literate school graduates able to interpret, analyse, and challenge statistical claims.

Statistics and Values in the Mathematics Curriculum

For many years the legacy of university introductory statistics courses, with an emphasis on technical terms and complex formulas, has convinced curriculum planners that statistics is just too difficult a subject for elementary or secondary school study. Fortunately this view is changing and the recent reform movement in mathematics education has proposed that statistics become a significant strand of the school mathematics program.

Collecting, representing, and processing data are activities of major importance to contemporary society. In the natural and social sciences, data are also summarized, analyzed, and transformed. These activities involve simulations and/or sampling, fitting curves, testing hypotheses, and drawing inferences. To enhance their social awareness and career opportunities, students should learn to apply these techniques in solving problems and in evaluating the myriad statistical claims they encounter in their daily lives. (National Council of Teachers of Mathematics [NCTM], 1989, p. 187)

Ministries of Education across Canada have responded to such calls for an expansion of the traditional school mathematics program, with all provinces and territories recently issuing documents that set statistics or data management as a strand of the mathematics curriculum from Grade 1 to graduation. The inclusion of statistics in the mathematics curriculum supports a healthy shift in the subject away from an almost exclusive link to the physical sciences and towards connections with the human domain. Statistics Canada, with its wealth of data on the Canadian human state, can play an important role in this shift of focus.

Research has shown that significant numbers of academically successful students react negatively to the traditional presentation of school mathematics; one that paints the discipline as abstract, impersonal, objective, and absolute (Tobias, 1990). When mathematics is given this image, female students in particular find the subject cold and uninviting (Buerk, 1985). In statistics, where one is required to make choices between methods of analysis and confront multiple interpretations, students meet a branch of mathematics that presents a more open picture of the subject. In addition, data management activities can address the needs of "connected knowers" (Belenky, Clinchy, Goldberger & Tarule, 1986), those who wish to link their learning to people rather than objects. Building functions that model social phenomena rather than the motion of physical objects can open new doors to mathematics study. Such exercises can be built around issues that have strong values or moral dimensions, and the intense discussions that arise can motivate further mathematical exploration.

Secondary school students, as they mature from adolescence to young adulthood, progress in moral development from a stage of "ideological experimentation" into a period of "ethical consolidation" (Rich & DeVitis, 1985). They are in the process of developing personal principles with respect to social justice, equity, and human rights. The mathematics classroom can and should serve as a place for students to struggle with these ideas. Conversely the students' emerging concerns and opinions can serve as a source of debates and questions that require data analysis for solution and thus support mathematics study. In the early high school years, students most often frame justice and equity concerns in terms of their own lives and those of their friends. Thus in these grades, activities are most effective if the issues and social data explored have local or personal connections. As students mature, they become more able to take a separate view and address value questions in more general terms. Issues and data for exploration in the senior years may thus be more global in nature. The resources available on the Statistics Canada website (www.statcan.ca) support investigation of questions with either focus.

A Sample Activity: Ontario Grade 12

The Grade 12 course, "Mathematics of Data Management" contained in Ontario's recently revised mathematics curriculum (Ontario Ministry of Education, 2000) requires that students "carry out a culminating project on a topic or issue of significance that requires the integration and application of the expectations of the course" (p. 54). The semi-open exploration described below can be conducted as a full-class activity in preparation for the more independent culminating project. This activity helps students: define an issue; formulate questions; locate, extract, and analyse data found on the Statistics Canada website; and make supported inferences and predictions from statistical measures.

In developing statistics projects for students the first step in the above

sequence, defining an issue, is often the most critical. A question that is personally meaningful and significant for a class or small group of students can provide the motivation required for extended effort on an independent project. Bringing the popular media into the mathematics classroom can help issues "naturally" arise. For instance, a couple of weeks of daily posting of the front page of a newspaper from any large urban centre will likely yield headlines that encourage questions concerning criminal activity from which the following sample investigation can flow. Discussion of a sequence of articles reporting on crimes, police activity, and court cases will raise questions such as, What is the level of crime in our society? How likely are we, individually, to be the victim of crime? Is crime on the rise or does newspaper reporting and poor memory just make it appear that this is the case? Class discussion of these issues can lead to the framing of a more focussed task such as:

> Some people claim that Canadian society is becoming increasingly dangerous and that tough new laws and punishment are required to return the country to the safer conditions of years past.
> Do you agree or disagree with this view?
> Is crime on the increase?
> Are new laws and punishment needed?

Individual classes, schools, or school neighbourhoods do not provide appropriate populations for sampling to accurately address questions that arise from significant social issues. Fortunately larger samples, representing a wider cross section of society, are available through the E-STAT utility on the StatCan website. Any Canadian educational institution can register for free access to E-STAT.

E-STAT data can be displayed in formats that make it compatible with a variety of school-based tools. In particular, Fathom (2000), a statistics package recently licenced by the Ontario Ministry of Education, may be employed to capture and analyse the data. Or alternatively, the TI InterActive! (2001) software may be used to download the information and send it on to a class set of the Ontario Ministry of Education supported TI-83 Plus calculators. The figures used in this article show the output of the graphing and statistics applications available on these calculators. The availability of information technologies makes the use of large data sets possible and allows students to focus on the fundamental tasks of: question formulation, location of appropriate data, selection of statistical techniques, and interpretation of results, rather than having to concentrate on routine calculations.

Table "252-0001 - Crimes, by actual offences, annual" is located by clicking through "Justice" and "Crimes and Offences" in the sequence of nested menus provided for E-STAT. In this table, students can find yearly reported criminal activity organized by type of crime (theft, murder, etc.) and geographic region (Canada or individual province or territory). Taking all reported criminal code offences for Canada and looking back to 1962, when this information was first gathered, the data generate the scatter plot shown in *Figure 1.*

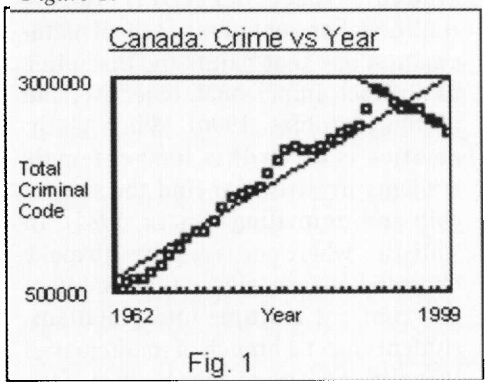

Fig. 1

This graph supports both sides of the argument. The overall trend since 1962 has been an increase in crime, but since 1991 there has been a reversal. Students can strengthen their debating points by performing linear regression to get the lines of best fit (shown in Figure 1) and the associated correlation coefficients. For the period 1962 to 1999, the coefficient (r) is .96, showing the strong overall upward trend. Those students who have argued that we are not at present in a period of rising crime can point to the fact that the line for 1991 to 1999 has r=-.98, showing a strong downward trend.

The class' first question may be answered, but the fact that the incidence of crime has changed over the years should motivate further investigation - Why does the rate of crime vary year to year? What causes people to commit more crime in one year than another? Debate on these issues can lead to the framing of a second more open task for the students.

> Some people do not see "law-and-order" policies as the best way to reduce crime. They claim that there are many social and demographic factors that are related to crime and that understanding these might help us work to reduce crime rates.
> Identify a social or demographic factor that might be related to crime.
> Select crime and social/demographic condition data from E-STAT to explore the relationship between your identified factor and the level of crime.

Discussion in one group of students may generate the suggestion that income levels could have an impact on crime. People who are suffering from poverty might be inclined to steal. With E-STAT data it is possible to examine such conjectures. Looking under "Personal finance and household finance" and "Income", students will not find poverty, but can locate table "202-0802 - Persons with low income before and after tax". This table can be used to obtain the yearly numbers of people, age 18 to 64, living on incomes below Statistics Canada's low income cut-off, and students may decide to use this measure as a proxy for poverty. When this time series is matched with that for crime, the students have a set of low income-crime pairs that can be tested for correlation (see Figure 2). Statistics Canada did not start recording the numbers of those living below the low income cut-off until 1980 and thus the set of low income-crime pairs and the graph are restricted.

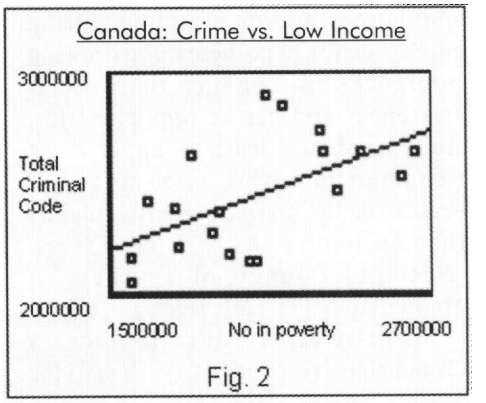

Fig. 2

The scatter plot, line of best fit and correlation coefficient (r=.57) show that those students arguing that low income and crime are related will not be able to construct a strong case using statistical reasoning. The lack of a strong connection should not be surprising since we are dealing with a set of complex interacting social conditions. Students learn that easy questions do not necessarily have simple answers.

Parallel to the first group's study, a second cluster of students might observe that young adult males appear to be involved in a disproportionate number of crimes and statistically test their conjecture. In *Figures 3 and 4*, data from table "051-0001 - Estimates of population, by age group and sex", found under "Population and demography" and "Population characteristics", have been used to give plots of crime versus the total number of males of ages 18 to 24 years *(Figure 3)* and 25 to 30 years *(Figure 4)*.

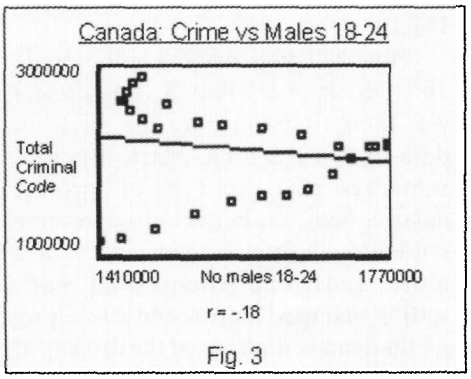

Fig. 3

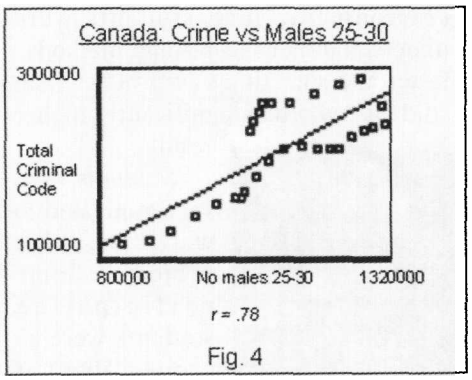

Fig. 4

Students are pleased to find that the population of the age group to which they belong (18-24) does not appear to be related to crime. In fact, there is a negative correlation (r=-.18) between the number of males ages 18 to 24 and the number of criminal code offences. On the other hand the data does reveal a stronger positive correlation (r=.78) between the population of males of ages 25 to 30 and the incidence of crime.

During whole-class reporting, the research groups can build on their results to suggest measures that our society might take in efforts to reduce crime and make Canada a safer place to live. Experience has shown that these debates can be intense, but with their grounding in data and accepted statistical methods they remain reasoned and civilized. Through such investigations, mathematics, technology, and Statistics Canada resources can be combined to support and encourage serious rational discussion of significant social issues. The aim is to have school graduates "who have been educated to recognize change, to be sensitive to problems caused by change, and who have the motivation and courage to sound alarms when entropy accelerates to a dangerous degree" - graduates who are "experts at *crap detecting*" (Postman & Weingartner, 1969. pp. 3-4).

Geoffrey Roulet is an Associate Professor of mathematics education at Queen's University. Prior to joining the Faculty of Education, Geoff taught secondary school mathematics, science, and computer science in Timmins, Ontario and worked as a school board and Ministry of Education consultant for K to 12 mathematics, computer science and computer applications in teaching and learning. Contact Geoffrey Roulet, Faculty of Education, Queen's Univ., Kingston, ON K7L 3N6.

Email: rouletg@educ.queensu.ca

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EDUCATION STATISTICS

From ***Education in Canada, 2000*** catalogue number 81-229-XIB:

"After 10 consecutive years of growth, elementary-secondary enrolments began decreasing in 1996-1997. The enrolment of 5.4 million students in 1998-1999 is still below the all-time high of 5.8 million attained in 1970-1971"

"The number of elementary-secondary educators increased from 296,900 in 1977-1998 to 300,300 in 1998-1999."

"Spending on education in current dollars reached $62.0 billion in 1997-1998."

"In 1997, the cost of education per capita of population was $2,067, 43% more than 10 years earlier, and for each person in the labour force, it was $4,040, a 43% increase over the same period."

"Between the Censuses of 1986 and 1996, the median number of years of formal schooling of Canada's adult population rose from 12.2 to 12.7."