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Preparing for the Future: Will Our University Graduates be Scientifically Literate?

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Article abstract

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More than 1000 student responses tothe survey were recorded. The ques-tions pertained to basic scientific princi-ples and processes (planetary motion,pasteurization, lasers, geologic time,changing seasons, atomic structure,photosynthesis, acidic fluids, plate tec-tonics, evolution and medicine), and en-vironmental issues (tropical forests,stratospheric ozone, greenhouse ef-fect, and acid rain). The group as awhole scored 66% correct. Three vari-ables producing main effects in level ofperformance on the test were gender,year and discipline. Males consistentlyscored higher than females at equiv-alent levels of education, students in thelife and physical sciences did betterthan those in the humanities or socialsciences, and test performance im-proved with level of education. Theeffect of the location of high school thestudent had attended was not signifi-cant. The highest scores on the testwere achieved by males in the fourthyear of the physical sciences (88% cor-rect). The questions with the lowest cor-rect response rate were those pertain-ing to geology (49% correct).

Issues in Canadian Geoscience

Preparing for the Future: Will Our University Graduates be Scientifically Literate?

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ABSTRACT

In today's technological society, it is becoming increasingly necessary to have an understanding of basic scientific facts and processes in order to make informed choices, both in one's personal activities and on issues of public policy. People in developed nations routinely make decisions on issues that have a scientific, technological and/or environmental component, either through their personal activities or through their work. Consequently, a level of knowledge of basic scientific facts and processes is an essential ingredient for informed decision making.

Recent surveys of adults in the United States, United Kingdom, and Canada have detected some indications of fundamental scientific illiteracy in the adult populations. Positions of responsibility that entail policy development and decision making are often held by university graduates. Therefore, a survey of undergraduate students at Erindale College of the University of Toronto was undertaken to determine the levels of knowledge of scientific principles and processes in this segment of the population.

More than 1000 student responses to the survey were recorded. The questions pertained to basic scientific principles and processes (planetary motion, pasteurization, lasers, geologic time, changing seasons, atomic structure, photosynthesis, acidic fluids, plate tectonics, evolution and medicine), and environmental issues (tropical forests, stratospheric ozone, greenhouse effect, and acid rain). The group as a whole scored 66% correct. Three variables producing main effects in level of performance on the test were gender, year and discipline. Males consistently scored higher than females at equivalent levels of education, students in the life and physical sciences did better than those in the humanities or social sciences, and test performance improved with level of education. The effect of the location of high school the student had attended was not significant. The highest scores on the test were achieved by males in the fourth year of the physical sciences (88% correct). The questions with the lowest correct response rate were those pertaining to geology (49% correct).

RÉSUMÉ

Dans la société technologique d'aujourd'hui, il devient de plus en plus impératif de posséder une culture scientifique de base des faits et processus naturels élémentaires pour faire des choix éclairés, cela autant dans nos activités personnelles que dans les situations portant sur des questions d'intérêt public. Dans les pays développés, les gens prennent régulièrement des décisions sur des questions comportant un aspect scientifique, technologique ou environnemental, et cela est valable autant dans leurs activités personnelles que dans leur travail. Aussi, est-il essentiel de posséder des connaissances scientifiques sur les faits et processus naturels élémentaires afin de pouvoir prendre des décisions éclairées.

Des enquêtes récentes menées aux États-Unis, au Royaume-Uni, et au Canada ont permis de détecter dans les populations adultes, une certaine ignorance des principes élémentaires naturels scientifiquement connus. Il arrive fréquemment que des personnes ayant une formation universitaire occupent des postes comportant des tâches d'élaboration de politiques et de prise de décisions. Une enquête a donc été entreprise auprès d'étudiants du premier cycle universitaire du *Erindale College* de l'*University of Toronto* afin de déterminer le niveau des connaissances scientifiques élémentaires dans ce segment de la population.

Plus de 1000 réponses d'étudiants ont été compilées. Les questions portaient sur les processus et les faits naturels élémentaires scientifiquement établis, tels (le mouvement des planètes, la pasteurisation, les lasers, le temps géologique, le changements des saisons, la structure atomique, la photosynthèse, les fluides acides, la tectonique de plaques, l'évolution et la médecine), et les questions environnementales telles (les forêts tropicales, l'ozone de la stratosphère, l'effet de serre, et les pluies acides). Le groupe a bien répondu dans 66% des cas. Les résultats ont varié considérablement en fonction de trois variables, soit le sexe du répondant, son niveau académique ainsi que la spécialité étudiée. Les résultats des garçons ont été en général meilleurs que ceux des filles, les étudiants en sciences de la vie et en sciences physiques ont obtenu de meilleurs résultats que ceux des sciences humaines et des sciences sociales et, les résultats ont été d'autant meilleurs que le niveau d'education des répondants était élevé. Le lieu de l'établissement secondaire fréquenté par l'étudiant n'avait pas d'incidence notable. Les meilleurs résultats ont été obtenus par des garçons en quatrième années dans le domaine des sciences physiques (88%). Les questions auxquelles on a le moins bien répondu portaient sur la géologie (49%).

INTRODUCTION

Scientific literacy is increasingly realized to be essential for informed decision making in populations of highly technological societies. Basic scientific literacy may be defined as having an understanding of the following (Einsiedel, 1990):

1) interconnectedness of society, science and technology,
2) the strengths as well as the weaknesses of scientific practice and process,
3) scientific methods of inquiry, and
4) scientific concepts and principles, in addition to a base of factual knowledge.

There are several compelling reasons for the desirability, or even necessity, of a scientifically literate society. Science and technology are now pervasive within the societies of the advanced industrialized nations. A very basic level of scientific literacy is therefore required for individuals to make informed choices, that affect not only themselves (including their personal safety), but the direction that society takes (Miller, 1983; The Royal Society, 1987; Durant *et al.*, 1989). Increasingly, public policy issues involve science, and scientific literacy is essential for informed debate and decision making, as well as for factually assessing the claims of vocal public interest groups (Miller, 1983; Durant *et al.*, 1989; Einsiedel, 1990; Miller, 1991). Additionally, a workforce that is comfortable with science and technology is central to the continued economic prosperity and development of industrialized nations (National Science Board, 1989; The Royal Society, 1987). Finally, science is a significant cultural accomplishment, and people's lives are enriched by an understanding of it (The Royal Society, 1987; Evans and Durant, 1989).

While basic scientific literacy is important for each individual in society, it is even more important for our decision makers. Persons in senior management of companies, government bureaucrats, and politicians make decisions that determine the future paths of research and industrial development for nations. At present, scientists tend to stay in active research, and, therefore, there are few in the upper levels of government and management with adequate science training (The Royal Society, 1987). University graduates frequently go on to hold these positions of authority, making decisions not just at a personal level, but at a level where they affect the direction of a company or public bureaucracy. Although all individuals in our societies make decisions both in their daily activities and at the polling booth that require a knowledge of science and technology, the decisions taken by those in positions of responsibility frequently carry much more weight. Thus, it is even more critical that these people are properly versed in science and technology. In a world in which science and technology will increasingly assume a major role, it is important to know the levels of scientific literacy of those who will make up this group of the population, namely the university students.

Recent surveys in Britain (Evans and Durant, 1989), the United States (most recently, Miller, 1991), and Canada (Einsiedel, 1990) have assessed the scientific literacy across random stratified samples of the populations. The purpose of the study presented in this paper was to measure the scientific literacy of university students at Erindale College of the University of Toronto, as a sample of university students in Canada. The results of the survey are presented and analyzed with respect to gender, level of education, discipline, and location of high school education. These results are then compared with those from the general population surveys. Understanding the level of scientific literacy in Canadian university students will aid educators in adjusting public, high school, and university curricula to eventually produce a more scientifically literate general population, and perhaps more importantly, leaders well versed in science and technology.

METHODOLOGY

The survey was conducted at Erindale College on the first day of the academic year in September, 1990. Most students were tested simultaneously, (a few classes were tested in the following hour), to avoid the possibility of students discussing the test or taking it twice. The test was administered by a group of graduate students to classes that ranged from first to fourth year across all disciplines (life sciences, physical sciences, social sciences, and humanities). Following testing protocol established by the University of Toronto for experiments involving human subjects, the students were informed that their participation was strictly voluntary. They were encouraged to participate by explaining to them that this was an opportunity to participate in research, which forms an important component of university life.

Sixteen questions of basic science, based on those topics addressed by other tests in Canada (Einsiedel, 1990), Britain and the United States (Durant *et al.*, 1989) were developed for this questionnaire. These other tests also asked questions dealing with perception and attitudes toward science. However, because the time available to test large numbers of students — necessary for significant statistical analysis — was limited, the Erindale study was restricted to a short test of basic knowledge and causal relationships. Questions pertaining to the demographics of the group were added for purposes of statistical analysis. Answers to the questionnaire were recorded on computer scan forms, then were read through the SCAN program on the University of Toronto Erindale College mainframe computer. Statistical analyses were performed using Statistical Package for the Social Sciences (SPSS).

The questions on this test were designed in a more complex manner than other tests (Durant *et al.*, 1989; Einsiedel, 1990; and Miller, 1991) to reduce the effect of guessing on subjects' scores. The questions were designed with five choices; the fifth response to each question was always "I don't

Table 1 Questionnaire

% Correct	
	1. By boiling milk, it is possible to
1.3	a) remove lead, aluminum, and other toxic metals
82.6	**b) destroy bacteria**
1.7	c) remove radioactive contamination
3.9	d) all of the above
10.5	e) I don't know
	2. Which of the following statements is FALSE? Tropical forests are important because
4.5	a) the roots of the plants hold the soil in place
27.3	b) during photosynthesis, plants consume carbon dioxide and release oxygen
7.5	c) they are the habitat of millions of species
57.1	**d) during photosynthesis, plants consume oxygen and release carbon dioxide**
3.6	e) I don't know
	3. Depletion of the ozone layer is considered to be a problem, because the ozone layer
81.3	**a) screens out many of the ultraviolet rays of the sun, which can cause skin cancer**
11.6	b) helps cool the earth from the sun's heat
2.3	c) is the earth's only protection from meteorite bombardment
2.0	d) represents the oxygen that we breathe
2.8	e) I don't know
	4. Which of the following statements is TRUE?
18.2	a) the earth goes around the sun once every day
1.7	b) the earth goes around the sun once every month
65.7	**c) the earth goes around the sun once every year**
7.5	d) the earth does not go around the sun, the sun goes around the earth
6.9	e) I don't know
	5. There is much concern being expressed about a possible greenhouse effect. If the greenhouse effect occurs to the earth, which of the following is NOT predicted to occur:
3.7	a) the earth may get hotter
13.7	b) sea level may rise
73.7	**c) the hours of daylight may increase**
2.3	d) polar ice caps may melt
6.6	e) I don't know what the greenhouse effect is
	6. Lasers work by
41.1	**a) concentrating light waves**
1.0	b) concentrating sound waves
3.4	c) concentrating radioactivity
34.7	d) shooting high energy particle beams
19.8	e) I don't know
	7. Which of the following statements is TRUE?
4.8	a) human beings and dinosaurs co-existed for approximately the past two million years, and then the dinosaurs went extinct
61.1	**b) human beings have inhabited the earth for approximately the past two million years, and the dinosaurs went extinct approximately 65 million years ago**
3.2	c) human beings and dinosaurs co-existed for hundreds of millions of years before the dinosaurs went extinct
4.7	d) human beings and dinosaurs co-existed approximately 10,000 years ago, when the earth was formed, and then the dinosaurs went extinct
26.2	e) I don't know when the dinosaurs lived
	8. The changing of the seasons, winter to spring, to summer, to fall, are caused by
29.9	a) the earth changing its distance to the sun
63.7	**b) the tilt of the earth's axis**
0.9	c) more clouds in winter than in summer
1.4	d) fluctuations in the sun's intensity, or brightness
4.1	e) I don't know
	9. Which one of the following statements is TRUE?
2.3	a) electrons are part of molecules which are part of atoms
4.0	b) protons are part of electrons which are part of molecules
60.7	**c) electrons are part of atoms which are part of molecules**
3.3	d) electrons are part of protons which are part of molecules
19.7	e) I don't know the structure of electrons, protons, atoms, or molecules
	10. Which of the following fluids is NOT acidic?
1.6	a) orange juice
77.6	**b) salad oil**
11.9	c) tomato juice
3.8	d) vinegar
5.1	e) I don't know
	11. Which one of the following is NOT a source of the chemicals which cause acid rain?
5.7	a) automobiles
10.1	b) coal fired electricity generating stations
65.8	**c) nuclear generating stations**
6.1	d) iron-ore or nickel smelters
12.3	e) I don't know what causes acid rain
	12. At one time, Africa, Europe, and North and South America were all one giant continent. This giant continent broke apart and the Atlantic Ocean started to form, and is still widening today. The time frame in which this continental drift has occurred is measured in
2.0	a) hundreds of years
6.8	b) tens to hundreds of thousands of years
39.1	**c) tens to hundreds of millions of years**
20.3	d) tens to hundreds of billions of years
31.8	e) I don't know

Table 1 continued ...

Table 1 continued ...

% Correct	
	13. Arteriosclerosis is a medical condition which is characterized by
5.1	a) muscle weakening and paralysis
1.2	b) loss of memory
66.1	**c) hardening of the arteries**
3.3	d) the inability of the blood to clot
24.3	e) I don't know
	14. Doctors tell a couple that their genetic make-up indicates that they've got a one in four chance of having a child with an inherited illness. This means that
0.7	a) if they have only three children, none will have the illness
5.3	b) if their first child has the illness, the next three will not
80.3	**c) each child the couple has will have the same risk of having the illness**
6.7	d) if their first three children are healthy, the fourth will have the illness
7.0	e) I don't know
	15. Mountain belts, such as the Himalayas, are formed by
9.3	a) earthquakes
44.1	**b) the collision of continents**
19.5	c) the eruption of volcanoes
6.7	d) radioactive disturbances in the earth's core
20.4	e) I don't know
	16. When scientists use the term DNA, it is to do with the study of
3.1	a) toxic chemicals in our water supply
1.3	b) rocks
89.9	**c) living organisms**
1.3	d) computers
4.4	e) I don't know
	17. How would you rank your level of understanding of general science? (For example, how do you think you did on this test?)
10.4	a) excellent
27.7	b) above average
46.7	c) average
11.4	d) below average
3.8	e) poor

Demographic Information

18. Please indicate your age bracket
 a) 18 years or younger
 b) 19-20 years
 c) 21-22 years
 d) 23-24 years
 d) 25 years or greater

19. What year are you in?
 a) first
 b) second
 c) third
 d) fourth
 e) other

20. Please indicate your gender
 a) female
 b) male

21. Please indicate your major field of study (only mark one)
 a) life sciences
 b) physical sciences
 c) social sciences
 d) humanities
 e) other

22. Please indicate where you obtained your secondary school education. Only mark one. If you moved during the time you attended secondary school, please indicate the region in which you spent most of your time.
 a) Mississauga
 b) Metropolitan Toronto
 c) other parts of Ontario
 d) other parts of Canada
 e) another country other than Canada

know". The odds of guessing correctlywere therefore only one in four, instead of one in three or one in two, as in the other tests. In the introduction to the test, the complete anonymity of the test results was stressed, to encourage the students to be as open and honest as possible about their levels of science knowledge, and, if they did not know the answer to a question, to acknowledge that, instead of guessing.

More than 1400 students were approached, and 1012 usable response forms were collected. This is interpreted to be another measure of the validity of the responses received in that those students who were not interested in co-operating in this research project did not participate.

RESULTS

The questionnaires were analyzed to examine the responses of the group as a whole, and were also investigated in terms of performance by year (level of university), gender and discipline in which the student was enrolled. A further analysis was done in which the question responses were grouped into subject areas, to look at performance in the different areas of science.

Overall Performance

The questions are listed in Table 1. The percentage responses by the whole group to each choice in the questions are shown, with the correct answer highlighted in bold. Total percent correct scores, broken down into discipline, gender and year are shown in Table 2 and Figure 1. For the whole group (n=1012) the mean percent correct was 66% ± 20%. When gender is considered, the females (n=564) scored on average 60% ± 20%, and males (n=448) scored 73% ± 18%.

Analysis of variance (ANOVA) is a statistical procedure that tests equality, or similarity, of populations by simultaneously considering both differences in means and in variances. ANOVA tests were performed to determine what effects, if any, were present between the different groupings. A 4×2×4 analysis of variance was performed with year (first through fourth), gender (female, male), and discipline of enrollment (life sciences, physical sciences, social sciences, and humanities) as the factors. A result of the random selection for testing is some very small subgroup sizes (*e.g.*, two fourth year females in the physical sciences, three fourth year males in the humanities). There are three statistically significant effects: year ($F=6.85$, $p<0.001$), gender ($F=34.85$, $p<0.001$), and discipline ($F=13.30$, $p<0.001$). Males consistently outscored females, and the test performance improved with years of education. Students in the life and physical sciences did significantly better than those in the humanities and social sciences. However, there were no interactions between these effects.

The area where students did their high school education was examined to see if there was any significant difference in test results based on geographic location (Table 1). There was found to be no significant effect from the location of schooling, even for those students who received their high school education outside Canada; in fact, that group did marginally better.

Perceptions of Performance

In question 17 (Table 1), the students were asked how they thought they did on the test. This was then compared with their actual scores. Their perception of their performance on the test correlated well with their scores for both males and females ($r=0.5800$, $P=0.000$). The fact that women felt that they had, and did indeed, score low ($r=0.5291$, $P=0.000$) is illustrative of the generally recognized lower academic self-esteem in mathematics and science often found in young female students (summarized in Tittle, 1986; Linn and Peterson, 1986).

Results by Discipline Area

Test scores were also analyzed by subject area (the questions categorized into each content area are shown in Table 3). Scores in chemistry, medicine, biology and global change were relatively good. All means were above 69%. The most poorly done sectors of the test were those dealing with physics and geology, with mean percent scores of 58% and 49%, respectively.

Comparison with Results from Other Tests

The Erindale questionnaire was designed with reference to previously used tests of scientific literacy, choosing topics for questions that were used in these other tests. The results of comparisons with three other surveys are shown in Table 4. These are merely qualitative comparisons, since the questions used in the various surveys were not identical in their wording or in their number of potential responses. Erindale students did better than the general public in the concept areas of pasteurization and radioactivity, timing of co-existence of humans and dinosaurs, the rate at which the Earth goes around the sun, atomic structure, and the structure of DNA. However, results were about the same for the understanding of lasers and genetics.

In terms of mean scores, the mean for Erindale students was 66%. The means for the general populations were 70% (Canada; Einsiedel, 1990), 62% (Britain; Evans and Durant, 1989) and 67% (United States; Evans and Durant, 1989). Strictly on the basis of mean scores, the Erindale students scored approximately the same as the stratified random sample in the general populations of Canada, Britain and the United States However, because the tests were not uniform, this may not be a valid conclusion.

DISCUSSION

The survey results show that there were significant differences in performance on the basis of gender, year and discipline. The lowest scores were attained by the students straight out of high school. Levels of test performance increased with year of schooling, which may be a function of exposure to science courses, differential attrition, or just an increased ability to do well due to experience in taking tests.

There were significant discrepancies in scores between disciplines. It is not surprising that those students enrolled in the life and physical sciences did well on the test. However, their scores still are low; one might reasonably expect perfect scores on questions of basic science from students of science. Students in the humanities and social sciences at Erindale are required to take one science course, usually an introduction to a specific science (*e.g.*, geology, psychology or chemistry). These specific introductory courses do not provide an overall grounding in the fundamentals of science, however. Based on the results of this survey, it is clear that this system does not equip students with a well-rounded understanding of basic science. Rather, to teach science to non-scientists, with the aim of giving them a basic vocabulary and

Table 2 Means and standard deviations by year, gender and discipline. The scores are out of a possible 16.

	Life Sciences			Physical Sciences			Social Sciences			Humanities		
	N	Mean	Standard Deviation	N	Mean	Standard Deviation	N	Mean	Standard Deviation	N	Mean	Standard Deviation
First Year												
female	44	10.341	3.213	52	9.923	3.371	113	8.381	3.072	69	8.942	2.955
male	40	12.775	2.516	56	11.804	2.400	85	11.318	2.900	23	9.783	2.610
Second Year												
female	32	10.344	2.858	9	11.000	3.202	49	9.020	3.017	35	8.114	3.445
male	20	12.500	2.705	45	12.133	3.145	55	10.764	2.906	15	10.533	2.800
Third Year												
female	36	11.972	2.348	10	11.500	1.841	25	8.720	2.354	24	9.625	3.005
male	12	13.750	1.288	15	12.267	2.712	13	11.154	2.794	6	11.333	2.658
Fourth Year												
female	20	11.000	3.026	2	14.000	2.828	8	10.875	2.900	13	10.308	3.093
male	16	12.500	1.506	9	14.111	1.691	4	11.500	2.380	3	13.333	0.577

understanding of the world around them, a general science course, subdivided among the different science departments, may be preferable.

There were marked differences between the male and female scores on the Erindale test, with the males scoring significantly higher. The lower scores of females may be due to an artifact of the testing process, with the "I don't know" option. Females are more likely to say "I don't know" than males, some of whom will guess (Linn and Peterson, 1986). However, the chances of a male guessing a correct answer are still only one in four. This is, therefore, not considered to be a factor that has strongly skewed the results.

The gender gap in performance on the Erindale test is strong at all levels, including the students just out of high school. In fact, many studies have shown that a gender difference in performance and interest in science and mathematics begins early in the high school years. Females show lower estimates of their own abilities (Tittle, 1986; Eccles, 1989), even as early as primary school (Tittle, 1986), and take fewer math courses than male students (Linn and Peterson, 1986). By the completion of high school, the tendency for males to outperform women in math and science is well established (Linn and Peterson, 1986).

Many of the problems with women in science stem from the pre-university education system, and this problem must first be addressed in this forum. Moreover, in the universities, most female non-science students do not catch up with males in terms of their basic levels of understanding, as even the fourth year females' performance on this test is inferior to that of males. Clearly, the present university system does not help solve the problem of women's low academic self-esteem. To have a society where half of the population has a poor understanding of science is a serious concern, particularly in light of the projected shortfalls in scientists and engineers predicted for the end of this decade. It would be useful to be able to call on the other half of the population to fill this demand, yet we are sadly failing in the science education of young women.

There was also an indication of some difference in performance by subject area (Table 3). Geology was the worst area on the test. In evaluating the significance of these comparisons, it should be considered that all questions may not be of the same level of difficulty, the chemistry questions being arguably the easiest of all. As well, there are not enough questions to significantly differentiate between disciplines. Nonetheless, the scores on fundamental aspects of geology (geologic time, plate tectonics, and evolution) reveal a poor level of knowledge in the tested population. This may in part be due to the fact that geology is rarely taught in the high schools or CEGEPs (Quebec), and if students do not take any geology courses while at university, they graduate with a baccalaureate degree and no understanding of the geology of planet Earth. While this hampers all individuals in their decision making, it is particularly detrimental to those graduates who go on to careers as scientists. It is increasingly recognized that interdisciplinary research contributes greatly to understanding human–environment interactions (Lillesand, 1993), and geology is an important component of environmental studies. If geology is not

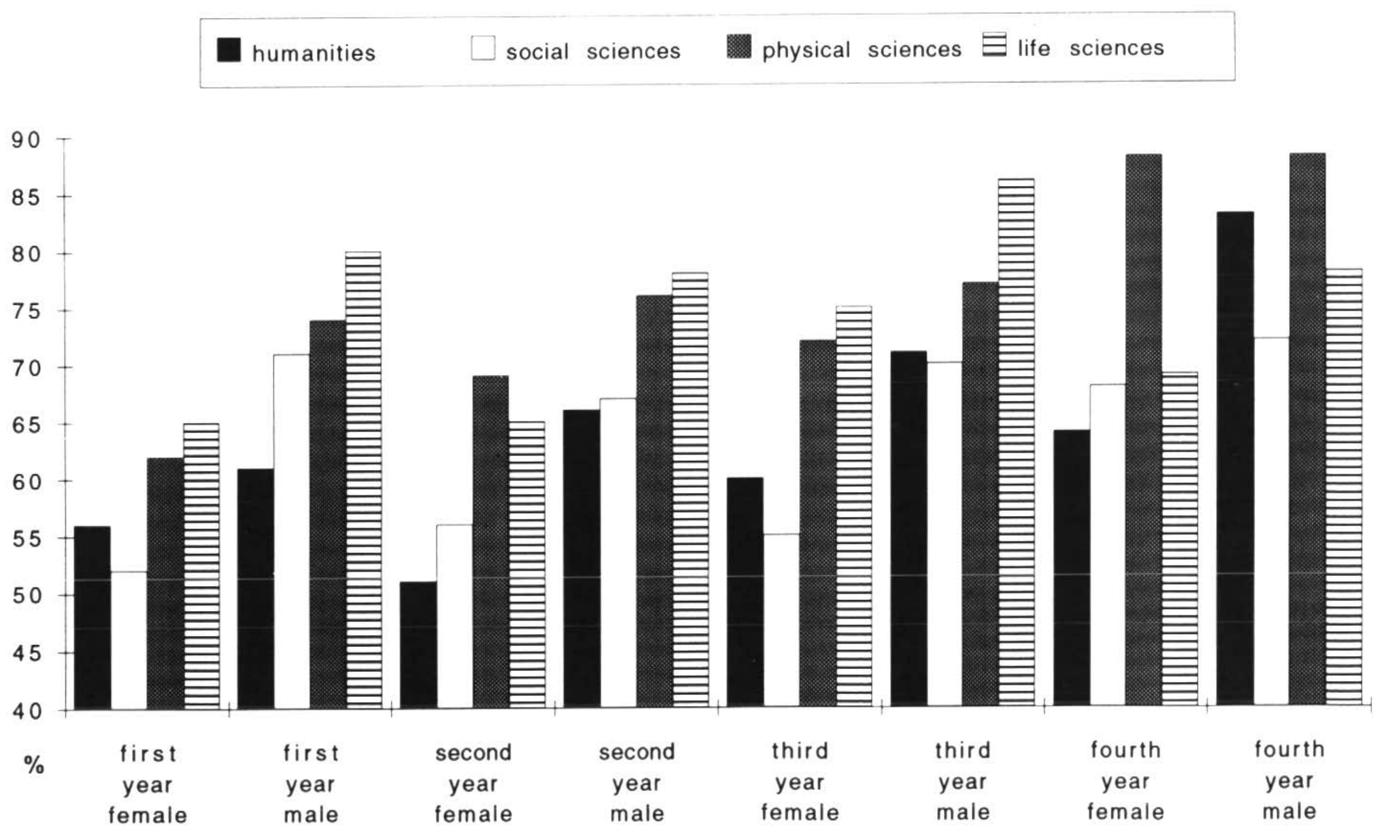

Figure 1 *Graphical representation of results (expressed as percentages) for year by gender by discipline. N values for each category are presented in Table 2.*

made a mandatory science course in our universities, then perhaps it should be included in the high school curricula.

As outlined in the introduction to this paper, university graduates represent the sector of the population that will go on to hold positions of authority, and make policy decisions with far-reaching implications for companies and governments. Individuals graduating from university and the rest of the population are faced with the increasing frequency of science and technology issues in the daily public purview, particularly with respect to environmental issues. Low levels of basic science knowledge have far-reaching implications. Universities are facing financial cuts now, with few replacements for retiring faculty. Will the general public and the decision makers, who are scientifically illiterate, understand the full dimensions of the crisis that has been engendered by the loss of faculty and low levels of research and development funding in science?

The nuclear industry is one which sparks emotional debates with often a poor understanding of facts. Can people who do not understand the basic structure of the atom (in this study, 40% of the people) make an informed, carefully thought out decision in this subject area, instead of an emotionally biased one? Will these people be able to differentiate and evaluate the potential risk associated with nuclear power stations from the real problems related to the emissions of fossil fuel stations? These are important questions in light of the opinion of many scientists that the potential risk associated with nuclear power generation is far less than the risks posed by climate change brought about by increased carbon combustion.

CONCLUSIONS

Scientific literacy is important to all members of technologically advanced societies, but is of particular significance in terms of the education of future policy makers, our university students. Results from this study show statistically significant differences among the levels of basic scientific knowledge in more than 1000 university students at Erindale College of the University of Toronto. Males perform better than females, those in the life and physical sciences perform better than those in the humanities and social sciences, and performance improves with year of education. It is clear that, coming out of high school, women have lower levels of basic science knowledge than men, and although the scores improve with schooling, this gender difference continues throughout university. We are, therefore, producing a graduating body where half the population, by gender, has a significantly lower level of understanding of basic science. This is damaging not only to the women themselves, but also to society as a whole. To rectify this situation, compulsory general science education should begin in primary schools, and continue through secondary school. At the university level, a general science course, taught by members of all science departments, should be mandatory for all first year students. This will lead to graduating a student body with at least a certain minimal understanding of how the world works. With the challenges facing the world, a scientifically literate population is a necessity.

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Table 3 **Comparison of results by subject area.**

Subject Area	Question Numbers	Mean Score
Chemistry	1, 10	80.2%
Medicine	13, 14	73.6%
Biology	2, 16	73.4%
Global Change	2, 3, 5, 11	69.6%
Physics	4, 6, 8, 9	57.9%
Geology	7, 12, 15	48.6%

Table 4 **Comparison of percent correct responses by subject area with other studies.**

Concept	Erindale College	Canada (Einsiedel, 1990)	United Kingdom (Durant *et al.*, 1989)	United States (Miller, 1990)
Pasteurization; Radioactivity	82.6	61.3	65.1	64.1
Humans and Dinosaurs	61.1	45.9	46.2	36.8
Earth goes around sun once a year	65.7	51.2	34.1	44.9
Lasers	41.1	38	41.8	36
Atomic Structure	60.7	46.7	30.9	42.7
Genetics	80.3	–	82	72
DNA	89.9	–	43.2	–

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REFERENCES

Durant, J.R., Evans, G.A. and Thomas, G.P., 1989, The public understanding of science: Nature, v. 340, p. 11-14.

Eccles, J.S., 1989, Bringing young women to math and science, *in* Crawford, M. and Gentry, M., eds., Gender and Thought: Psychological Perspectives: Springer-Verlag, New York, p. 36-58.

Einsiedel, E.F., 1990, Scientific Literacy: A Survey of Adult Canadians: unpublished report to the Social Sciences and Humanities Reseach Council of Canada, and Industry, Science and Technology Canada, 50 p.

Evans, G. and Durant, J., 1989, Understanding of science in Britain and the USA, *in* Jowell, R., Witherspoon, S. and Brook, L., eds., British Social Attitudes, special international report: Gower Publishing Company Ltd., London, England, p. 105-119.

Lillesand, T.M., 1993, The "grayware" required to deal with global change issues: Photogrammetric Engineering and Remote Sensing, v. 59, p. 961-968.

Linn, M.C. and Peterson, A.C., 1986, A meta-analysis of gender differences in spatial ability: implications for mathematics and science achievement, *in* Hyde, J.S. and Linn, M.C., eds., The Psychology of Gender: Advances Through Meta-Analysis: The John Hopkins University Press, Baltimore, MD, p. 67-101.

Miller, J.D., 1983, Scientific literacy: a conceptual and empirical review: Daedalus, v. 112, p. 29-48.

Miller, J.D., 1991, The Public Understanding of Science & Technology in the United States, 1990: a report to the National Science Foundation, 120 p.

National Science Board, 1989, Public science literacy and attitudes toward science and technology, Chapter 8, *in* Science and Engineering Indicators – 1989: United States Government Printing Office, Washington, D.C., (NSB 89-1), p. 161-177.

Royal Society, The, 1987, The Public Understanding of Science: report of a Royal Society ad hoc group endorsed by the Council of the Royal Society, 41 p.

Tittle, C.K., 1986, Gender research and education: American Psychologist, v. 41, p. 1161-1168.

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