Background Study for the Science Council of Canada

June 1973
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Education and Jobs

Career patterns among selected
Canadian science graduates
with international comparisons

by A.D. Boyd and A.C. Gross

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What I find wrong is the stark division now existing between the years of formal education and entry into the work of life. Education has become to a great extent a mere acquirement of a legal qualification to enter a closed profession, in place of being a process undertaken for its own sake....

Thus, by the time the student has reached middle high school on his way to college, he has already joined a sort of 'convoy' that moves slowly down the widening stream of education, always at the pace of the slowest. It sweeps along majestically, working puzzles, muttering declensions, answering quizzes and translating 'parlez-vous'.

Any ordinary bright boy could strike out from the convoy, like a sloop from a fleet, like a fast motorboat from among freighters, and distance it by two years. By the time the heavy convoy reached its goal, he would have been there already for years, married with one and a half children, an established position, whiskers, debts, life. He would watch the convoy discharging its spectacle neotypes, thirty years old, timid in the daylight, shuddering at life, having lived for thirty years on other people's money. That's a little exaggerated, but it's good enough.

Stephen Leacock, *Too Much College*, 1939.

One of the most pressing needs at this time is for better criteria for judging "good" or "bad" utilization. These are harder to set in a free society which gives priority to individuals freely to choose the occupation they will follow or the industry in which they will work. This suggests the need to create a climate in which rigidities are removed and the range of choice extended.

Statement of the Canada Department of Citizenship and Immigration, *Policy Conference on Highly Qualified Manpower*, OECD, Paris, 1966.

Archibald D. Boyd

Dr. Boyd was born in Nova Scotia. He received his BA degree in 1949 from St. Francis Xavier University, Nova Scotia, and a Diploma in Education in 1950. In 1952, he received an MA in Economics from the University of Toronto and a PhD in economics from the University of Ottawa in 1967.

Between 1952 and 1955, he lectured in economics at St. Francis Xavier University. In 1955, he was appointed to the Nova Scotia Department of Trade and Industry as an economic adviser on regional industrial development. In 1958, he joined the Federal Department of Labour (later the Department of Manpower and Immigration) and became Head of the Highly Qualified Manpower Research Section. During this time, Dr. Boyd also worked on the staff of the Royal Commission on Health Services, and was associated with the OECD Committee on Educational Investment and Planning. Later, he was a member of the Canadian Delegation to the Intergovernmental Conference on the Utilization of Highly Qualified Manpower in 1971. In 1968, he became a senior economist in the Program Division of the Department of Regional Economic Expansion with responsibilities for electric power and water programs. Since 1969, he has been a science adviser with the Science Council.

Dr. Boyd is author or co-author of a number of monographs and articles dealing with highly qualified manpower, including *Report of the Royal Commission on Health Services*, Volume 2, "Section on Auxiliary Health Manpower", 1964, and "The Labour Market Experience of Engineers in North America", *Industrial Relations*, December 1971.

Andrew C. Gross

Professor Gross was born in Hungary and attended universities in Canada and the United States. He received a BSc in Electrical Engineering from Case Institute of Technology, Cleveland, Ohio, in 1957, an MBA from Western Reserve University, Cleveland, Ohio, in 1962, and a PhD in Economics from The Ohio State University, Columbus, in 1968. He received various academic awards, including scholarships in Ohio, and a fellowship at the University of Saskatchewan (Saskatoon). He is a member of two national honorary fraternities and is a registered engineer in Ohio and Saskatchewan.

Between 1957 and 1962, he worked as a staff engineer with Ohio Edison Company, Sohio Pipe Line and Ohio Department of Highways. During the mid-60s he was employed as a summer research associate with Battelle Memorial Institute, Dominion Bureau of Statistics, and Predicasts, Inc. Between 1966 and 1968, he was an instructor at Lehigh University, and since 1968 he has been at Cleveland State University where he is currently an associate professor. During the past three years, he has acted as a consultant to the Science Council of Canada and Predicasts, Inc., a business research organization.

Professor Gross is author or co-author of several monographs and about twenty articles in various academic, technical and trade journals in the field of labour, manpower, business research, marketing, engineering and education.

Professor Gross is a member of the American Economic Association, Canadian Economics Association, Industrial Relations Research Association, and other professional groups. He was a summer fellow at the Economics-in-Action Program, Case Western Reserve University in 1968, and participated in the Second World Congress on Industrial Relations, Geneva, 1970.

Foreword

This study focusses on the relation between education and work by examining how a group of physical science graduates relate their education to their jobs. Changes in the degree of specialization in science education and employment have important implications for the content of, and attitudes toward, science education.

The topic of the study is particularly timely. The value of science education for young people and the rôle of the universities themselves in society is being debated vigorously. The insights provided by this study should contribute to the discussion.

The authors realize that some readers will wish the study had roamed more broadly and included other forms of post-secondary education and gone more deeply into the area chosen. Others will wish that the psychological and sociological aspects had been probed more thoroughly. The decision to limit this present study was deliberate. We invite others to take up these important complementary studies. We agree they should be done.

In common with other background studies published by the Council, this study represents the views of the authors and are not necessarily the views of the Council. The Council is publishing this study because it makes an important contribution to our understanding in this area.

We would particularly like to thank those who gave generously of their time by taking part in the survey.

P.D. McTaggart-Cowan,
Executive Director,
Science Council of Canada

Acknowledgements

It is a pleasure to acknowledge the help of the science graduates who responded to the survey questionnaire. We are indebted to the university alumni associations which provided us with the addresses of their graduates. We also wish to thank the Canadian Association of Physicists and the Chemical Institute of Canada, who co-sponsored the special survey along with the Science Council.

We also want to thank those on the Science Council staff and elsewhere who commented on the study. In particular, we would like to thank Dr. P.D. McTaggart-Cowan for his stimulating and constructive criticism and suggestions.

In addition, we would like to thank Mrs. Marilyn Cayer, Mr. Chris Frank, Mr. K.J. Gibson and Mr. I.A. MacDonald, who assisted us with various parts of the study, and Mr. Leo Fahey, who prepared the figures. Finally, we would like to thank Mme Lucille Lussier and Miss Beverley Wood, who typed various drafts of the study.

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Summary

Nature abhors a vacuum, says an old scientific adage. Since this study is about scientists, we tried to follow the advice and, accordingly, did *not* conduct our study in isolation. We attempted to bring together findings from other studies and other countries – and to complement these with a primary survey of our own. Indeed, if the results are meaningful and if they have merit, it is because we are trying to present them in context, in a comparative framework. Only this way can we learn from the past and gain perspective: only this way can we hope to apply the lessons of today to the problems of tomorrow.

This study originated from the conviction that the education-work relationship is important, especially to professionals and, within that group, to science graduates. The study received impetus from a variety of other sources: 1) the recent levelling-off in university enrolment and in expenditures for research activities, 2) concern about the state of the labour market for science graduates, 3) the desire to develop and apply better criteria for judging "good" or "bad" utilization, and 4) the desire to make a contribution, however modest, to the problems faced by Canadian society, science graduates, and those concerned with the rôle of science and scientists in society.

After a brief survey and review of already published information, we chose not to conduct another supply-demand analysis, but to use a different approach – a case study, in depth, examining the education, employment and utilization pattern of selected Canadian science graduates. We were especially interested in how such men and women – honour graduates in chemistry and physics – utilize their education in the world of work. By and large, we relied on their answers to a mail questionnaire. In a sense, we accepted their responses as a correct picture reflecting their work environment, assessments of education, and general attitudes. Such perceptions of past and present situations are real indeed to the respondents. Furthermore, we have taken into account more objective and other related information. And finally, a complementary study on the university-industry interface is being prepared at the Science Council; this survey of educational institutions and business firms – that is, of employers – should provide insights from "the other side".

Our findings can be summarized by types of source and by areas of consideration. We shall briefly comment on both consistencies and contradictions in the findings.

I. Review and Analysis of Published Information in Canada

Education

Enrolment in and facilities for science programs at Canadian universities have been expanding at a rapid rate, with some slowdown experienced in recent years. The pure fields of science proved to be more popular at the undergraduate level, applied fields favoured by more in graduate school – a trend which is desirable. The undergraduate curriculum has become more "tightly packed", content has been upgraded, and high standards remained in effect. There are both danger and encouraging signals ahead for aca-

demia, ranging from anti-education sentiment to a willingness to try new ideas.

Employment

Canadian science graduates, like other professionals, have enjoyed rising absolute and relative earnings in the past two decades, with some slowdown in the past few years. The unemployment rate has been negligible. Their distribution in occupational, industrial and functional terms reflects the requirements of employers. All of the above also holds true for immigrant scientists whose numbers have grown very fast in the 1960s, compared to the 1950s. Mobility of scientists has been pronounced with Ontario attracting a large share. While the past decades have been seller's labour markets, a balance or buyer's market is expected now for the 1970s.

Utilization

If one considers labour force participation rates, then Canadian scientists are fully utilized. Women also – especially before and after the childbearing years – show high participation rates. Age and earnings profiles have generally been upward sloping. Scientists, once resident but now living outside Canada, tended to be younger and to have higher educational qualifications than those employed in Canada.

II. Primary Survey of Canadian Science (Honour) Graduates – Chemistry or Physics, Classes of 1954, 1959 and 1964

Education

The honours curriculum – a rigorous, demanding program – has changed much in content but little in its structure over the past twenty years: emphasis remained on the given field or the major subject, with elective courses accounting for only 10 to 15 per cent of the total "load". Our respondents would have preferred no less rigour, but more flexibility and more electives in their undergraduate programs; a few universities have now moved in that direction. The sufficiency rating given to non-science courses is rated quite low. Undergraduates' grade performance has been declining, but it can still be rated relatively high. Enrolment in graduate schools has been high; about four-fifths of the respondents pursued advanced degrees. Honour graduates with high grades are encouraged to remain in academia. Graduates have the potential for a variety of sub-fields during graduate school. Science students come from a relatively high socio-economic background and list interest/challenge most frequently as the reason for their occupational choice. They are profession- rather than career-oriented. A surprisingly large proportion participate in continuing education, including non-degree, non-credit courses.

Employment

At first sight, employment patterns confirm the traditional view of honour graduates as future academicians – almost one-third of our respondents belong to the professorial ranks. But an equally large proportion function as physical scientists, with the remainder in a variety of occupations. Many in academia, industry or government undertake administrative tasks as promotions occur. Thus, honour graduates in science can and do fill a wide range of positions and functions. Data on job offers, job changes, starting and current earnings indicate the existence of a strong labour market in the 1955–1970 period, favourable to the graduates. Although unaffected by the problems of the most recent graduates, our slightly older group exhibits concern over the changing trend in the labour market, now favouring employers.

Utilization

There is practically no unemployment among the graduates surveyed and labour force participation rates are high, although a small minority is still in graduate school. Satisfaction with the work environment is rated generally as average or slightly above average. Intrinsic factors – recognition, achievement, responsibility – are the key motivators or satisfiers, but different ones appear in different settings. It is notable that those in high school teaching see their work as socially useful, a characteristic seldom mentioned by college professors. When the labour market is tight, security rises in importance as a source of satisfaction. About three-fifths of the respondents make considerable use of their undergraduate major; one-fourth make little or no use of it. One-third state that the specific major was a prerequisite to the current job, but an equal proportion agree that a related field would have served as well. On the whole, there is a "reasonably" good match between education (including graduate schooling) and jobs: but there is room for improvement. About two-thirds of the graduates would choose the same undergraduate field of study and the same proportion would recommend it, in today's world, to others.

III. Relevant Findings and Comparisons from the International Scene

Education

Science graduates in developed countries, especially the U.S. and U.K., come from relatively high socio-economic backgrounds. They exhibit similar traits and characteristics. Those in the U.S. tend to be more career and industry oriented than those in Canada or the U.K. Worldwide trends in science education show a trend toward curricular reforms, flexibility, broader training, and catering to the non-specialist.

Employment

Science graduates generally enjoy high earnings and lack of unemployment in developed economies. There are differences in industrial, occupational and functional deployment among the countries, reflecting the structure of the underlying economy in each case and a host of complex factors. Yet the percentage of U.S. science graduates in industry and their U.K. counterparts in high schools (especially those with advanced degrees) is surprisingly high when compared with the Canadians.

Utilization

Regarding the utilization of college education at work, U.S. science graduates show consistently higher scores. In other words, a larger proportion of the former claim that 1) the field they majored in is a prerequisite, 2) the university education they had is of considerable use, and 3) someone with a different qualification could perform the work they are now doing. The figures are about 80 per cent for the U.S. and 55–60 per cent for the Canadian graduates. The explanation lies in a better match between type of work sought and the actual job situation which, in turn, is a reflection of far more possibilities for specialization in the vast and more complex economy of the U.S. Put another way, Canadians use their general college training more in a less specialized setting. The Canadian and U.K. comparisons reveal very great similarities in job characteristics and satisfiers, even within given industrial sectors. Specifically, as one important example illustrates, science graduates in both Canada and Britain who now teach in high schools rate the "social usefulness" aspect of their work as very important and as satisfying. This and related findings indicate that science graduates can find fulfilling functions outside the more traditional fields of university classrooms and industrial (or other type) laboratories.

IV. Overview and Conclusions

What do the three types of sources, the various findings, and the concomitant analysis indicate? When we draw conclusions and comparisons, the following salient points should be emphasized.

1) An overview of published information gives a highly satisfactory rating in regard to the education, employment and utilization patterns of Canadian science graduates.

2) A more in-depth view of the same situation via a primary survey and international comparisons – and accepting the graduates' statements at face value – gives a less satisfactory picture of these patterns.

3) There is evidence that individuals and institutions are aware of the problems currently arising and are dealing with them. The need for restructuring science curricula is especially demonstrated; the rigid nature of such programs at most Canadian universities is in need of reassessment. Specific implications and recommendations on other aspects are given at the end of the study.

I. Introduction

One of the greatest challenges that Canadian society faces is the full development of its human resources to meet both economic and social goals. The demand for education has rapidly increased in the past two decades. A number of influences have resulted in greatly increased university enrolment. Firstly, more students – including many women – have demanded a university education to prepare for a career; expanding facilities and a general increase in incomes have enabled them to obtain one. Secondly, higher education came to be viewed as the key to good earnings and satisfying jobs. Thus in the early 1960s, many new institutions of higher education were built, financed, and staffed while others expanded rapidly. Now there is concern about the ability of society to finance equitably university education, along with other competing social services, such as medical care, renovation of cities, and assistance to people with low incomes. The very structure and performance of academia are being subjected to close scrutiny. Young people are questioning the goal of education and growth as expressed by university degrees and the increase in gross national product. New life styles are emerging; in some the work ethic itself is absent. These trends signify both stresses and challenges.

Although this study deliberately focusses on the relationship between education and work, it does not suggest that this is what education is mostly about. Education is for life and there is, after all, much more to life than making a living. Also, there is more to learning than formal education. But the importance of education-job issues, for some time to come, easily justified the decision to point the study in this direction.

The Canadian job market has undergone an almost complete turnabout during the early 1970s. From a scramble to staff our rapidly expanding universities and industrial organizations during the 1960s (often done with the help of recruits from abroad), the scene has recently changed to one of deep concern among graduates about the availability of employment. A slower rate of growth in employment, the emergence of new trading blocks, and the imposition of restrictions by the United States, have raised new questions about Canada's economic development as well as about the kind of education and work which will need to be done in an uncertain future.

Past governmental decisions resulted in a massive expansion of educational facilities. Large graduating class sizes combined with the current economic turndown now produce a much "softer" job market for highly qualified manpower. Nobody foresaw the change exactly, even five years ago, although there were occasional clear warnings. There is a danger that the current dissatisfaction of students and decision makers may result in stop-go kinds of decisions about careers, education, and manpower policy, thus adding to the short-term instability of the system. To what extent can a reliable and long-term context be provided to those who must make such decisions? This is one key question our study seeks to answer.

One thing appears certain: the largest annual graduating classes in the history of Canada, which will be produced in the 1970s, must be prepared to cope with a different environment than their counterparts in the previous decade. The end of simple linear growth will demand, from those who leave school, college, or university, greater adaptability to changing social and economic requirements. In view of an expected decline in traditional jobs for highly qualified manpower (e.g., in research and academic institutions), how can the education and employment system meet the needs of both young people and society at large? This is another question we plan to face in this study.

After a long run decline, the birth rate in Canada rose during World War II and after. This along with a high rate of immigration in the postwar years had a major impact on school and university enrolment in the 1950s and 1960s and now affects the labour force of the 1970s. The earlier decades saw an explosive growth in the demand for highly educated people, especially for teachers at all levels. In the 1960s, the labour force grew by 30 per cent and the annual number of post-secondary graduates by 154 per cent.[1] During the 1970s, the labour force is expected to grow by 28 per cent compared with a continuing rapid growth rate in post-secondary graduates of some 147 per cent.[2] Even a continuation of the current slower rate of increase in university enrolment will not alter significantly the ratio of new graduates to the labour force. The 1970s will be a decade of readjustment and consolidation, of relative abundance or at least balance, rather than one of scarcity of highly qualified manpower. The decline in the birth rate which occurred in recent years will in turn have a deep impact on school attendance, university enrolment, and labour force in the 1980s and beyond. But we must be careful to avoid alternating periods of shortages and surpluses!

The adjustment of supply is slower than changes in the economic environment and in the demand for graduates. A large part of the increased demand for highly qualified manpower which arose in the 1960s was met by immigration into Canada. This pattern may not be repeated in the 1970s and 1980s. Changing patterns of demand for graduates in the 1970s will require increased concern with utilization and the adaptability of the graduates. We shall examine the trends of the postwar years for clues which they can offer us about the future. While such historical analysis is highly useful, it tells us little about current work patterns. The available statistics generally relate to broad categories and the information on college graduates' utilization patterns is especially meager.

A key part of the study, accordingly, was a primary survey focussing on patterns of education, employment, *and* utilization among selected Canadian science graduates. A four-page questionnaire, in English and French versions, was mailed in late 1970 to all those men and women who received a bachelor's degree with honours in physical science from a Canadian university in 1954, 1959 and 1964. Included were those who received a BSc (Hon.) or a BA (Hon.) in chemistry, physics, or a combination of one of these fields with another. The survey, initiated by the Science Council of Canada, was co-sponsored by the Canadian Association of Physicists and the Chemical Institute of Canada.

The response to the survey was highly gratifying. From a total of 913 potential respondents, 633 replied for a response rate of almost 70 per cent. Usable questionnaires totalled 619, with 114 from the class of 1954, 178 from the class of 1959, and 327 from the class of 1964. The response rate compares favorably with those obtained in official government surveys (except the Census of Canada) and very favorably with privately sponsored surveys.

Since certain statistics on Canadian scientists are available in ample supply from the publications of Statistics Canada, the Department of Labour, the Department of Manpower and Immigration, the Science Council of Canada, and certain private groups, our survey emphasized aspects not found in published works.[3] We review briefly pertinent published statistics and then present newly collected data on science curricula and science graduates. The data from our primary survey are a mixture of qualitative and quantitative aspects and generally constitute an assessment of the university and work environment by the science graduates. Such subjective views, ideally in combination with data from employers and government sources, need to be considered by policy-makers at all levels. Whenever possible, we make references to and comparisons with other, similar surveys.

The aim of the present study is to assess the education-employment adjustment processes for Canadian science manpower during the late 1950s and 1960s in order to gain insights which will be useful in dealing with problems of the 1970s. Using both objective and subjective information, we analyze individuals' education and career patterns, against changes in the educational system and trends in the economy, and, to deepen the perspective, we compare these analyses with related studies in Canada and abroad. We chose physical scientists for the investigation because of their importance and the possibility of comparing the results with a similar study of Canadian engineers done in 1967–68.[4] How well did the science graduates of the late 1950s and 1960s integrate into the world of work? How easily did they make the adjustment from education to employment? How do those performing research and teaching utilize their education? How effectively is the education of science graduates used in other areas of activity? The experience of the latter may be of greater significance, because they may well be the majority of tomorrow, as opportunities in teaching and research now are not expanding fast. The success of graduates who sought jobs outside the traditional areas can give clues to the kind of education-employment relationships existing in the changed conditions of the 1970s and 1980s.

Among the key issues of the 1970s will be the nature of higher education, the supply-demand situation for highly qualified manpower, and the "proper" utilization of college graduates. The first issue ranges from the structure of curricula to the forms of continuing education.[5] Though the labour market of the 1970s will be undoubtedly tighter than that of the 1960s, relatively few college graduates will be found among the ranks of the long term unemployed (though the exceptions will make the headlines). It appears they will be able to compete quite successfully for jobs. But this raises the third issue: will these jobs utilize their education and provide personal satisfaction? Will they be jobs that meet society's requirements, however expressed? The nature of the manpower issue for the highly educated will be utilization rather than simply education or unemployment. Changing job-utilization patterns for science graduates have profound implications for future patterns of education, for curricula, and for labour market adjustment policies.

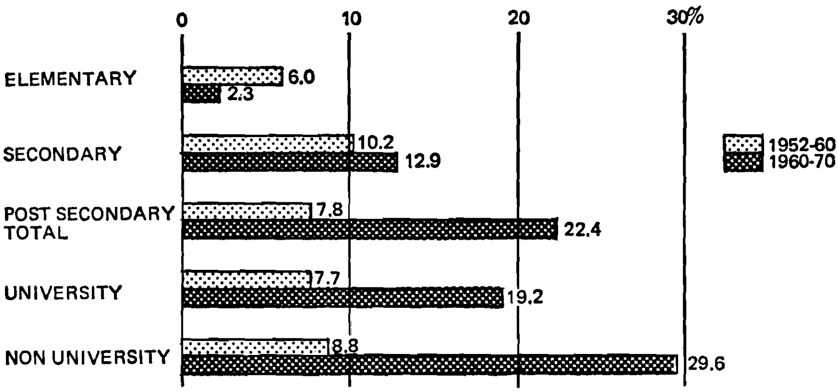
The outline of the chapters is as follows. The next section gives a brief overview of the social and economic events during the postwar period. The part following describes and analyzes the science curricula of universities and then presents the results of the survey in detail. In the fourth section, findings from our primary survey are compared with the results of similar studies in and out of Canada. In the final portion, we draw several conclusions and explore the broader policy implications for individuals, organizations, and institutions.

II. Trends in the Education, Employment and Utilization of Canadian Physical Scientists

The social and economic events of the last two decades have influenced greatly the career patterns of Canadian scientists. The most spectacular of those events is the increase in the number of people attending schools and universities. The combination of high postwar birth rates and immigration, plus rising ratios of all age groups enrolled at all educational levels, have produced the largest expansion of enrolment in the history of Canadian educational institutions. As the demographic wave passed through the various age groups, first elementary and then secondary school enrolment rose rapidly in the 1950s and 1960s, then the wave reached the universities and colleges.

Between 1952 and 1960, the average annual increase in post-secondary enrolment was about 8 per cent; this figure rose to over 22 per cent per year between 1960 and 1970 (Figure II.1). Full-time university enrolment rose from 64 000 in 1951–52 to almost 300 000 in 1970 (Table A.1, in Appendix A). Enrolment in community colleges, *Colleges d'Enseignment Général et Professionnel* (CEGEP's), and other non-university post-secondary institutions rose at the even greater rate of almost 30 per cent per annum between 1960 and 1970, compared with 19 per cent per year for university enrol-

Figure II.1–Average Annual Per Cent Change in Enrolment, Canadian Educational Institutions, 1952–1970



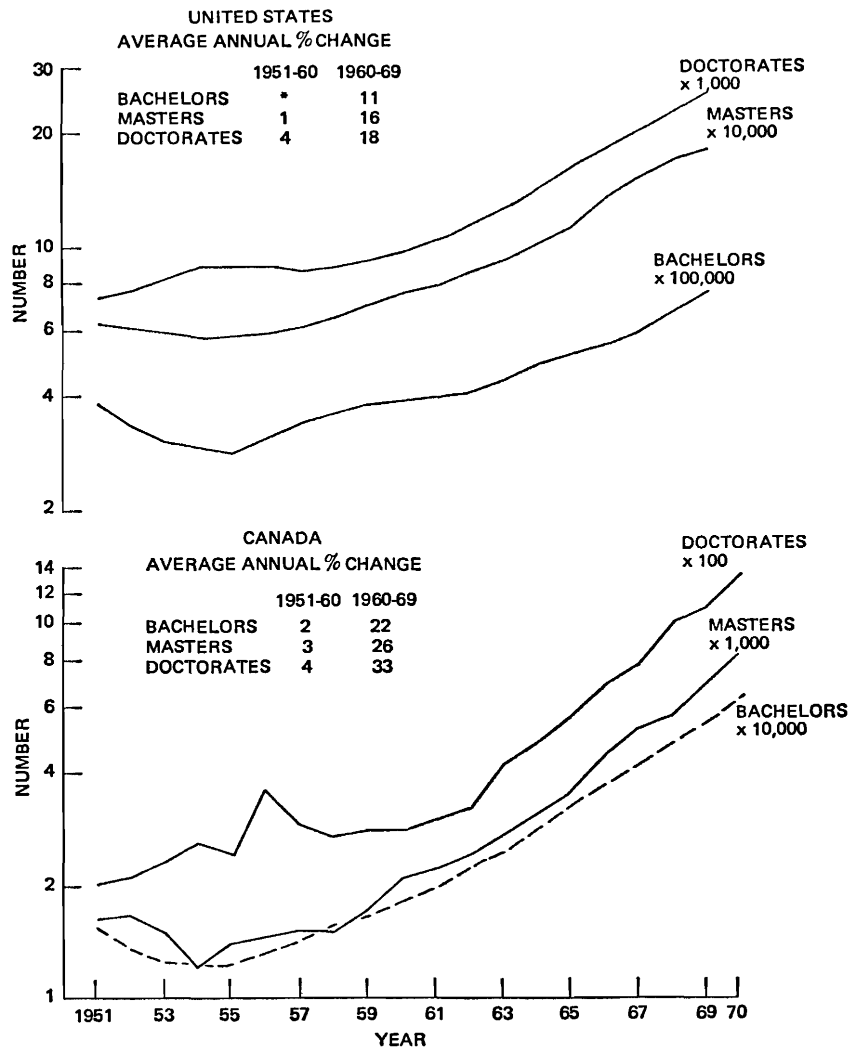
Source: Z.E. Zsigmond and C.J. Wenaas, *Enrolment in Educational Institutions by Province, 1951-2 to 1980-1*, Economic Council of Canada Staff Study No. 25, Information Canada, Ottawa, 1970.
Statistics Canada, *Advanced Statistics of Education, 1970-71*, Information Canada, Ottawa, August, 1970.

ment. However, part of the increase in community colleges' enrolment, particularly in Quebec, consisted of students in the university transfer section. The rise in university and post-secondary enrolment was due primarily to a large proportion of the college-age group deciding to take higher education and secondarily to a numerical increase in the size of the group itself. Between 1960 and 1970, the university-age population (18–24 years) increased only 57 per cent compared with an almost 200 per cent increase in university enrolment.

Higher Education

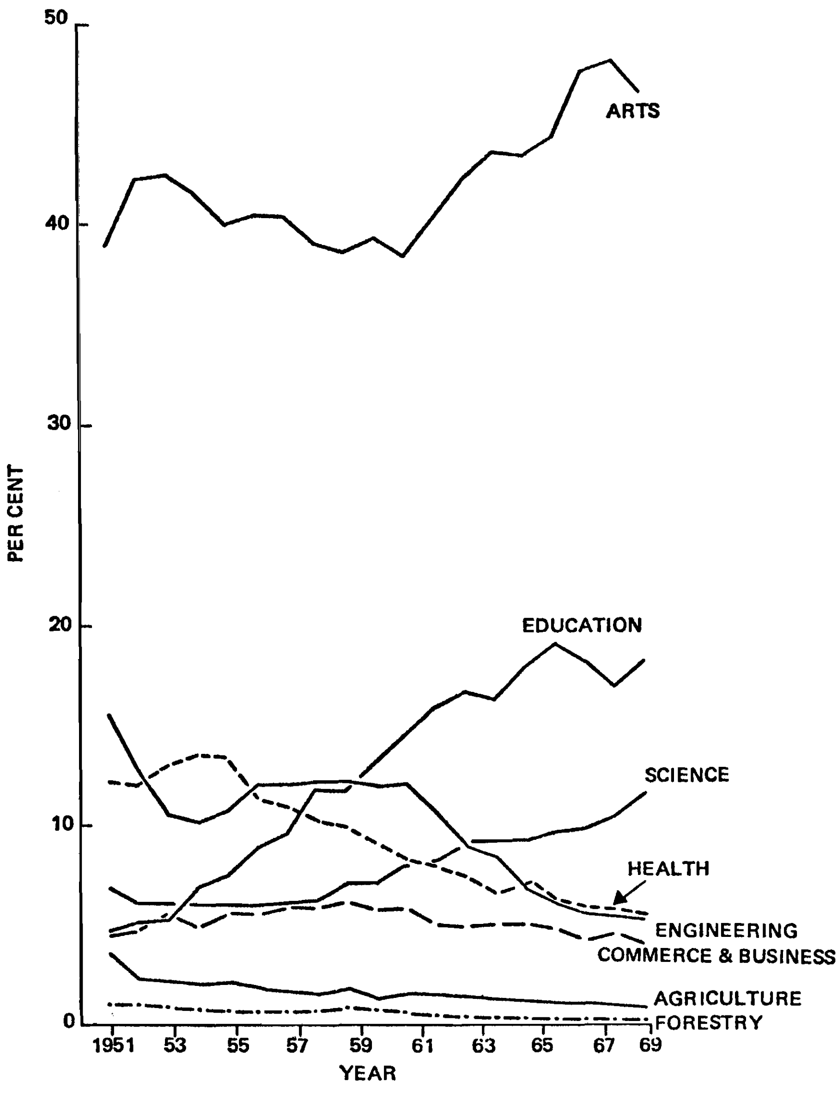
The number of university degrees granted increased rapidly during the 1960s. Between 1951 and 1969 the number of bachelor's and first professional degrees granted by Canadian universities increased more than three-fold, while master's and doctoral degrees increased more than five-fold (Figure II.2). In addition to the more rapid rate of growth at the post-graduate level, certain fields of study at the bachelor and first degree level grew more rapidly (Figure II.3 and Table A.2). The most striking increases were in the numbers of arts and education graduates. Next were science graduates who increased dramatically from 6.9 to 11.7 per cent of all first

Figure II.2–Degrees Granted in Canadian and U.S. Universities, 1951–70



Source: Table A.2.

Figure II.3–Per Cent Distribution of Bachelor Graduates by Field of Study, Canada, 1951–1969



Source: Table A.3.

degree graduates. Part of this increase, however, is a reflection of differences in the way the degrees were reported by universities, with BSc being given increasingly in place of the BA.[1] Even allowing for this, a movement toward science did occur.

The swing to "pure" fields of arts and science undergraduate degrees was accompanied by notable decreases in the proportion of graduates in a number of "applied" fields (except education) including engineering, health sciences, commerce and business, agriculture, and forestry. Engineering declined from 15.6 to 5.4 per cent of all bachelor's degrees and health professions from 12.2 to 5.5 per cent between 1951 and 1969. A similar swing from applied fields also occurred in the United States. If one views true education as an intellectual pursuit in the arts and sciences, then this trend is encouraging. It may also serve well as a broad foundation for graduate studies and for potential mobility among diverse occupations.

The pattern for science at all levels in both Canada and the United States is summarized in Tables II.1 and II.2. Within science itself, however, there was a swing towards the biological sciences. At the honours bachelor's level, the total number of degrees increased rapidly between 1961 and 1969, but honours degrees in the biological sciences rose from 6.5 to 10.7 per cent of all honours degrees. The number of honours graduates in physical sciences increased three-fold over the same period, but declined as a proportion of all honours degrees from 29.1 to 19.8 per cent. During these years, the growth of employment opportunities in teaching, the attraction of rapidly increasing scientific research, and the glamour of the space age undoubtedly attracted people to pure arts and sciences. In addition, the accommodation of the large numbers of new students may have been easier to accomplish in arts and science than in applied faculties such as medicine and engineering. Finally, students may have chosen to postpone their decisions about careers and to leave specialization for graduate schools.

Table II.1–Degrees in Science as a Proportion of all Degrees, by Level, Canada and the United States, 1951, 1961, 1969.

Degree Level	1951		1961		1969	
	Percentage		Percentage		Percentage	
	Canada	U.S.	Canada	U.S.	Canada	U.S.
Bachelors[1], Science, Total	6.9	10.4	8.2	11.7	11.7	11.4
Masters, Science, Total	–	11.3	20.1	11.1	16.5	10.7
Biological	–	3.8	6.7	3.0	5.8	3.3
Mathematics and Statistics	–	1.8	2.6	2.8	3.7	3.7
Physical	–	5.1	10.7	4.8	6.9	3.1
Doctoral, Science, Total	–	36.5	55.1	33.4	49.7	31.8
Biological	–	10.9	22.0	11.3	16.3	11.9
Mathematics and Statistics	–	2.5	2.6	3.3	4.8	4.4
Physical	–	22.9	30.5	18.8	28.6	15.3

[1]Data are not available by fields of study at the first degree level, except for honours degrees. Between 1961 and 1969, the proportion of all honours degrees represented by biological sciences increased from 5.8 to 10.7 per cent, while physical sciences declined from 29.1 to 19.8 per cent.
Source: N.M. Meltz, *Patterns of University Graduations by Field of Study in Ontario, Canada and the United States, 1950–1 to 1968–9*, Institute for Policy Analysis, University of Toronto, 1971.

Table II.2–Bachelor Graduates in Honours Science, by General Area, Canada, 1961 and 1969[1].

General Area	1961		1969	
	No.	%	No.	%
Biological Sciences	92	6.5	551	10.7
Physical Sciences	412	29.1	1020	19.8
Social Sciences	316	22.3	1522	29.6
Humanities	578	40.8	1855	36.6
Other	19	1.3	171	3.3
Total	**1417**	**100 0**	**5149**	**100.0**

[1]Data for 1970 are available but are not strictly comparable with 1969, as the classification of areas was changed by Statistics Canada.
Source: Statistics Canada. *Survey of Higher Education, Part II*, Degrees, Staff and Summary. Various issues. Cat. No. 81-211.

At the post-graduate degree level during the 1960s, there was a swing away from pure science towards the applied fields of engineering and education (Tables A.3 and A.4). This shift occurred in both Canada and the United States. In Canada, at the doctoral level there was a decline in the proportion of biological and an increase in physical science graduates during the 1960s. Insofar as trends at the bachelor's and master's level foreshadow those at the doctoral level, we can expect to see an increase in the proportion of PhDs in the life sciences and a corresponding decline in the physical sciences. The exact contours of future enrolment in institutions of higher education cannot be foreseen, but it is safe to say that growth rates will slacken, fluctuations in popularity of different fields will continue, and specialization will tend to take place at the graduate rather than undergraduate levels.

Demand

The expansion of university enrolment in the 1960s was accompanied by rising public expenditures on graduate studies and research. In a group of 49 Canadian universities, enrolment expanded by 13 per cent per annum between 1960 and 1968, from about 80 000 to 211 000, while operating expenditures rose about twice as fast, by 24 per cent per annum from $115 million to $627 million. Annual operating costs per full-time student rose to over $3 000 in 1968–69 from $1 500 in 1960–61. Federal support by the National Research Council, Medical Research Council, and the Canada Council for scientific activities in the universities rose from $12.1 to $132.6 million between 1960 and 1971.[2] These funds helped to support research at the post-graduate level, particularly in the sciences. Governments also attempted to augment the supply of university teachers by increasing grants and scholarships for graduate studies.

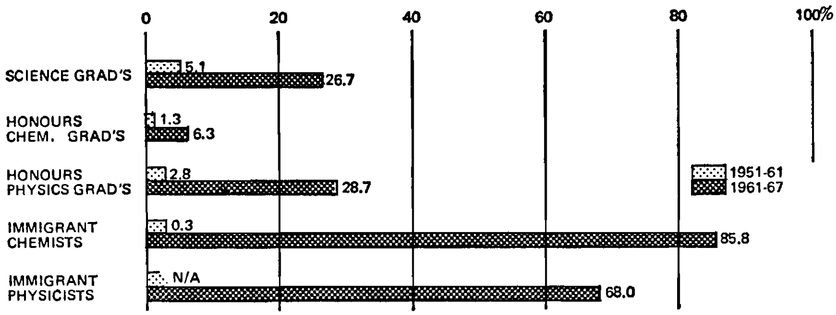
During the 1950s, in contrast to previous decades, the market for highly qualified manpower, including scientists, was characterized by a strong surge of demand, broken by short slack periods. During the latter half of the 1956–66 period, gross national product increased by 54 per cent compared with only 23 per cent during the first half.[3] The 1960s were a golden decade in the labour market for scientists and other professionals, but the 1970s will be more spartan in terms of public and private support, economic expansion, and job opportunities.

Immigration

The Canadian market for scientific manpower is very sensitive to economic conditions here and abroad; in times of rapid economic growth the in-flow of professionals was strongly encouraged. For Canada, immigration served as a source of quickly available manpower, when domestic supply fell short of demand. During the post-war period, immigration played a large part in filling the gap created by the rapidly growing demand for highly qualified manpower and by the lag in domestic supply during the 1960s. The important contribution of immigration as a proportion of total labour force growth declined from one-half between 1956 and 1961 to less than one-third from 1961 to 1966.[4]

But in the case of highly qualified manpower, immigration continued to increase rapidly. The proportion of new immigrants planning to enter professional occupations increased from 13 to 22 per cent between 1957 and 1966. Between 1951 and 1960, gross immigration accounted for 44 to 60 per cent of all new entrants to professional occupations.[5] Between 1961 and 1967, although annual graduations in pure science increased rapidly from 1 600 to 4 200, the annual immigration of chemists and physicists increased even faster, (Figure II.4 and Table A.5), thereby helping to fill the manpower gap during these years.

Figure II.4–Average Annual Per Cent Change in Numbers of Science Graduates and Immigrants, Canada, 1951–1967



Source: Table A.5.

Careers

Employment Patterns

One of the indicators of career progress is the earnings profile. The age-earnings profile for managerial and professional employees slopes upward and peaks between the ages of 40 and 64. A survey of engineers and scientists by the Department of Manpower and Immigration in 1967 showed that earnings of physical and social scientists peaked between the ages of 55 and 59.[6] Personal characteristics such as age and education as well as external factors such as employment opportunities contribute to the determination of an individual's earning capacity. The study found that earnings of physical scientists were above those of life and social scientists and only slightly below those of engineers. Physical scientists in executive positions earned about $4 000 more per year than those in research and development, $15 000 versus $11 000. Median earnings of those in universities exceeded salaries in manufacturing or the federal government. Certainly university salaries at that time were attractive to anyone willing and qualified to teach at that level.

The activities of the highly qualified manpower work force were also examined in the 1967 Department of Manpower and Immigration Survey. About two-thirds of all engineers and scientists, compared with only one-half of physical scientists, were employed by industry (outside the education and government sectors). However, a much larger proportion of those with advanced degrees were employed by governments or educational institutions, e.g., one-third of those with honours bachelor's degrees compared with 80 per cent of those with PhDs. In addition, as experience increased there was a rapid shift to executive and administrative positions, with 86 per cent of those in administrative jobs having ten or more years of experience, compared with only 67 per cent of those who were in research and development activities. However, fewer of the physical scientists were in executive or supervisory positions, 25 per cent versus 36 per cent of all scientists and engineers as a group.

The 1967 Survey[6] also showed that the proportion of those with bachelor's degrees who obtain employment outside the province where they got their degree ranged from about 25 to about 70 per cent depending upon the population of the province. The corresponding figure for PhDs ranged from 35 to 75 per cent. In 1967, about 32 per cent of the scientists and engineers in Canada were employed outside the province where they completed high school. Most movement took place from other provinces to Ontario and Quebec, where population, industry, and research laboratories are concentrated and new educational institutions have been created. Graduates of the two provinces have little need to move. Of course, language and cultural factors are undoubtedly important in explaining the large proportion of Quebec graduates who sought and found employment in their home province.

Utilization Patterns

The utilization of highly qualified manpower is a multi-dimensional concept including the relation between an individual's work and the goals of society; his education and the aims of his employer; and the aspirations of the individual himself.[7] The relation between field of study and field of work was examined in the 1967 study by the Department of Manpower and Immigration. About four-fifths of all scientists and engineers were found to be employed in the same broad field in which they took their highest degree, but only 58 per cent of physical scientists were employed in physical science occupations. This could mean that they were occupationally more flexible than other kinds of graduates, that there was a lack of opportunities in related occupations, or, simply, that the definitions of occupational boundaries were narrower for physical sciences.

While we do have general statistics on the field of study and the field of activity for science and other college graduates – such as those mentioned above – detailed information is scarce or non-existent on utilization patterns. By utilization we mean far more than what is subsumed under the labels of "current function" and "annual earnings" or even "professional activities." Ideally, we would like to answer the following questions:

1.) Was the specific undergraduate preparation a prerequisite for the job?

2.) Is the undergraduate curriculum useful – i.e., applied – on the job?

3.) How well is the graduate degree, if any, utilized in the performance of the work?

4.) Could other preparation serve equally as well in the performance of the tasks?

Such questions, we found, have been answered so far only for Canadian engineers and for scientists (as well as others) outside Canada. In our view, it was important to assess these patterns for at least a select group of Canadian science graduates. At some future date, the analysis could be extended to all Canadian college graduates and the answers from individuals matched with those available from organizations (including supervisors' ratings, personnel files, etc.).

Retrospect and Prospect

In the past decade, demand for highly qualified manpower, including immigrants, expanded more rapidly than job opportunities for the labour force as a whole. Although there are few data for scientists as such, the market for Canadian science graduates was generally strong during most of the period covered by this study.[8] At the undergraduate level, the arts or pure science option, far from being only of cultural value, provided a broad foundation. It also proved vocationally useful, particularly to students who planned to enter the teaching profession. (In fact, as we will see later, a substantial proportion of the science graduates who took honours bachelor's degrees became elementary and secondary level teachers.) At the post-graduate level, pressures for university expansion encouraged graduates to return to the educational system as teachers or professors. As far as academic jobs were concerned, the 1960s may be regarded in retrospect as a "golden age" from the viewpoint of the science graduate degree job seeker. But this was a time of rapidly increasing demand for Canadian science graduates and immigrants (both those with and without advanced degrees) on the part of industry and government as well.

In evaluating the experiences of our respondents from three graduating classes in the primary survey, the generally favourable economic conditions which prevailed following their graduation need to be kept in mind. Indications are that the situation facing science (and other) graduates in the 1970s will be different as both enrolment and economic growth slacken. The question now is: what can we learn from the past and present patterns of education, employment, and utilization which will guide us in the 1970s and 1980s?

III. Results of the Survey

This chapter focusses on the relationship between education and employment, or as some put it, the ivory tower and the market place. Changes in science curricula at Canadian universities between 1950 and 1970 are examined first, followed by an assessment by science graduates of the usefulness of university education on the job. Then, both objective information on career patterns as well as subjective views are used to further examine the education-employment relationship.

The background for the presentation is the interaction of science and society in the West during the years following World War II. With hindsight, three distinct periods can be detected, all of which reflect the phenomenon of "organized science". The period 1945–1957 is characterized by solid scientific accomplishments and by great admiration on the part of the public. The post-Sputnik era of 1957–1969 can be described as the age of specialists and, particularly in the U.S., of government contracts, but also as a period when a gap was developing between scientists and society at large. The third period, barely two years old, marks a reversal in the popular support of scientific activities. There is suddenly much concern with national science policies, federal support, the labour market for scientists, and the process of education in the physical sciences. In this atmosphere of reassessment, we take a retrospective look at *certain* aspects of science education in Canada.

The chapter is divided into four main sub-sections: science education, in particular, the structure and sufficiency of selected undergraduate science curricula and reactions to them; the background of respondents; employment patterns by occupation, industry and geographic location; and utilization patterns or the education-job interface.

Science Education

Selected Canadian University Science Curricula, 1950–1970

An examination was made of the proportion of student time devoted to required and elective optional courses in the honours chemistry and physics programs of Canadian universities. There was some variation in the length of the programs: in most universities (e.g. University of Toronto, University of Alberta), it was a four-year program following senior matriculation, but in some (e.g. University of British Columbia) it required only four years following junior matriculation. A shorter honours program may leave less room for flexibility in choice of courses. In general, we did not find that variations in the length of the program or entry requirements affected the arguments presented here.

A study of Canadian higher education in physics or chemistry, including the major and general options, would require a more comprehensive analysis. In focussing on honours programs, we emphasize format rather than content and cite comparative data on the structure of chemistry programs from other countries. The discussion below gives highlights from more detailed analyses already published elsewhere.[1]

The Structure of Honours Chemistry and Physics Programs in Canada

The rôle which chemistry played in Canada's industrial development and higher education is well-documented in *Chemical Canada* by Warrington and Newbold[2], in *Chemistry and Chemical Engineering*, Special Study No. 9 by the Science Council of Canada[3], and in a series of journal articles.[2, 4, 5, 6, 7] Such volumes in the field of physics proved to be more scarce, though we found the journal, *Physics in Canada*, a useful source. In these publications, the expansion in postwar enrolments at universities, the proliferation of fields of study and course offerings, and the emphasis on graduate studies are discussed. Relatively little space is devoted to contents of courses, except to note the general tendency toward introduction of more advanced subject matter in the earlier years. There is little or no discussion of the format of curricula; yet the present study found that graduates viewed their education as a "package" and considered structure quite important.

In the analysis of the structure of these two undergraduate honours programs at Canadian universities, we chose to look at the proportion of time devoted to different areas. Calendars of Canadian universities were examined for the years 1950-51, 1960-61, and 1970-71, with each program considered in terms of total hours offered, including laboratory work. Required courses were classified into the following areas: the major (chemistry or physics), other physical sciences, mathematics, applied science or technology, social sciences and business, humanities, and all others (e.g. physical education). The elective portion was divided into three sub-groups: all physical sciences; the humanities, social sciences and business; and completely "free choices". The results, for all universities combined, are shown in Tables III.1 and III.3 (physics) and Tables III.2 and III.4 (chemistry).

The statistics show that the general profile of the honours science curriculum changed little between 1950 and 1970 in Canada. The figures do hide changes over time at a given university, as well as the diversity which exists among universities in a given year, but examination of such detailed statistics merely underscores the stable situation shown in the

Table III.1–Structure of the Undergraduate Physics Curriculum (Honours Program) at Canadian Universities, 1950–70

Subject Areas	Percentage Distribution		
	1950	1960	1970
Required Courses:			
Physics	53	52	55
Other physical sciences	7	8	5
Mathematics	19	19	22
Engineering, technology	1	>0	>0
Social sciences, business	1	>0	>0
Humanities, languages	8	8	3
Other	1	2	1
Subtotal–Required Courses	*90*	*89*	*86*
Elective Courses:			
Physical sciences, mathematics	2	2	4
Social sciences, humanities	3	4	5
Free Choice	5	5	5
Subtotal–Elective Courses	*10*	*11*	*15*
Grand Total	**100**	**100**	**100**
Number of Universities included	13	18	26

Note: Totals may not add due to rounding. For further details and international comparisons, see *Physics in Canada*, 27(6), July 1971.
Source: Primary research by authors and I.A. MacDonald using university calendars.

Table III.2–Structure of the Undergraduate Chemistry Curriculum (Honours Program) at Canadian Universities, 1950–1970

Subject Areas	Percentage Distribution		
	1950	1960	1970
Required Courses:			
Chemistry	48	50	56
Other physical sciences	16	16	12
Mathematics	10	11	12
Engineering, technology	1	>0	1
Social sciences, business	2	1	1
Humanities, languages	7	7	3
Other	1	2	1
Subtotal–Required Courses	*85*	*87*	*86*
Elective Courses:			
Physical sciences, mathematics	2	3	4
Social sciences, humanities	4	4	6
Free choice	10	6	6
Subtotal–Elective Courses	*16*	*13*	*14*
Grand Total	**100**	**100**	**100**
Number of Universities included	13	18	26

Note: Totals may not add due to rounding.
Source: Primary research by the authors and I.A. MacDonald using university calendars.

Table III.3–Structure of the Undergraduate Physics Curriculum at Selected U.S. and Soviet Universities (percentage distribution)

Subject Areas	1	2	3	4	5
	Carnegie Tech., U.S.A. 1950	Carnegie Tech., U.S.A. 1970	MIT (Mass. Inst. Tech.), U.S.A. 1955	Kharkov State, (USSR) 1955	Typical U.S. Program 1963
Required Courses:					
Physics	22	31	37	36	36
Other physical sciences	10	11	8	9	2
Mathematics	13	5	5	11	14
Engineering, technology	0	3	>0	7	4
Social sciences, business	32	12	8	15	12
Humanities, languages		12	8		9
Other	3	5	>0	8	3
Subtotal	*80*	*79*	*65*	*86*	*80*
Elective Courses:					
Physical sciences, math.			14	13	19
Social sciences, humanities	20	22	5	2	1
Free choice			16		
Subtotal	*20*	*22*	*35*	*15*	*20*
Grand Total	**100**	**100**	**100**	**100**	**100**

Note: Totals may not add due to rounding.
Source: Columns 1 and 2: Primary Research by the authors and I.A. MacDonald.
Columns 3 and 4: A.G. Korol, *Soviet Education for Science and Technology*, MIT Press, Cambridge, 1957. Pages 260-61. Program for U.S.S.R. differs little from that shown for 1959 in N. DeWitt, *Education and Professional Employment in the U.S.S.R.*, United States Government Printing Office for National Science Foundation, Washington, 1959. Page 713.
Column 5: *Undergraduate Curricula Patterns, 1962-3*, USDHEW, Washington, 1963. Reprinted in M.C. McCarthy, *The Employment of Highly Specialized Graduates*, Science Policy Studies No. 3, Her Majesty's Stationery Office, London, 1968. Page 5.

tables. The time devoted to the major (about 50 per cent of the total curriculum) remained unchanged or increased slightly; the proportion given to other science courses and the humanities (about 35 per cent) exhibited similar stability. The percentage devoted to elective courses, only 15 per cent of the total hours, remained unchanged. While we do not dispute the fact that content has changed and while it is possible that "what used to be physics is now chemistry and vice versa"[8] the format of the honours curriculum can be described as stable and rigid.

Table III.4–Structure of the Undergraduate Chemistry Curriculum at Selected U.S. and Soviet Universities (percentage distribution)

Subject Areas	1 Carnegie Tech., 1950	2 Carnegie Tech., 1970	3 Typical U.S.A. Program 1963	4 Typical U.S.S.R. Program 1955
Required Courses:				
Chemistry	33	45	36	47
Other physical sciences	8	5	2	10
Mathematics	13	>0	14	9
Engineering, technology	2	>0	4	4
Social sciences, business	4	3	12	8
Humanities, languages	17	13	9	9
Other	5	>0	3	3
Subtotal	*82*	*66*	*80*	*90*
Elective Courses:				
Physical sciences, mathematics	8	14	19	
Social sciences, humanities	5	16	1	10
Free choice	5	5		
Subtotal	*18*	*35*	*20*	*10*
Grand Total	**100**	**100**	**100**	**100**

Note: Totals may not add due to rounding.
Source: Columns 1 and 2: Primary research by the authors and I.A. MacDonald.
Column 3: *Undergraduate Curricula Patterns, 1962-63*, United States Department of Health, Education and Welfare, Washington, D.C., 1963. Reprinted in M.C. McCarthy, *The Employment of Highly Specialized Graduates*, Science Policy Studies No. 3, Her Majesty's Stationery Office, London, 1968. Page 5.
Column 4: N. DeWitt, *Education and Professional Employment in the U.S.S.R.*, United States Government Printing Office for National Science Foundation, Washington, D.C., 1964. Page 716. Distribution shows little change from the 1955 curriculum, also shown on the same page.

On the other hand, *content* has changed greatly, with advanced topics receiving attention at an earlier date. What used to be graduate material is now taught during the junior and senior undergraduate years and the topics formerly covered at that level have now been introduced at the lower undergraduate level. This content change has been confirmed by physics and chemistry professors, administrative officials, and by occasional articles or books. But the focus, in this study, is on structure. Since the structure appears to be rigid it will be argued that more freedom and diversity – but no less rigour – should be introduced.

Three curricula comparisons, based on work-sheets not shown, are of possible interest: old versus newly-established, French-Canadian versus English-Canadian, and Canadian versus non-Canadian universities. In the first case, newly-established universities tend to opt for a stricter program; the time devoted to elective and to non-science courses is less than at the older universities. Perhaps newly-founded departments and colleges seek to "prove themselves" to their students and their sister institutions by setting the share devoted to required courses at a relatively high level.

Comparing French- and English-language curricula, the former were found to emphasize science and other required courses more strongly. For example, currently 70 per cent of the student's time is devoted to chemistry courses at Laval and at Sherbrooke compared to the general average of 56 per cent. (In an earlier study, we found similar results in electrical engineering programs; French-language universities had more intensive science-mathematics requirements.)[9] Several factors probably account for the above situation.

1. Students in Quebec entered universities after only 11 years of prior studies.

2. Recently, industrialization and science have been emphasized in Quebec.

3. The French-Canadian system resembled European higher education patterns. Graduates of classical colleges had many courses in the humanities *before* entry to university.

The comparison between Canadian and non-Canadian programs is made in the following paragraphs.

International Comparisons of Science Curricula

From a variety of sources, we compiled the figures shown in Tables III.3 and III.4. These statistics reveal the structure of "general" programs in the U.S. and the U.S.S.R. One is immediately struck by the much lower proportion of time devoted to required courses in the U.S. as compared to Canada. At the same time, there is a strong resemblance – at least on the surface – between Soviet and Canadian curricula. Several explanations can be offered for these phenomena.

The simplest and likeliest explanation for the difference between the Canadian and the U.S. programs is that the latter is a major or general program rather than a highly concentrated honours curriculum. In other words, the Canadian BSc (Hon.) is nearly a "professional" degree and as such is not as flexible. The U.S. college education is a more liberal one; it has been called also, as a result of many options, a cafeteria-style offering.[10] Still another factor might be that U.S. engineering programs, more so than Canadian ones, became science-based, yet retained a professional-vocational approach; this allowed science curricula to have a humanities orientation. Finally, the differing industrial settings of the two economies and possibly different national values are likely to influence university course offerings.

While more time is devoted to humanities and the social sciences in the U.S.S.R. program than in Canada, many of these Soviet courses deal with rather prescribed ideology and philosophy. The proportion of time devoted to electives is low, signifying a close science-orientation and possibly some rigidity. Western visitors to the U.S.S.R. remarked on the relative length of the Soviet science curriculum (five to five and a half years), on its exacting nature, and on further specialization at the graduate level.[11] It is possible that Soviet students get a broader education, in an informal manner either before entering university or during breaks in the academic year, than the figures suggest, but we have no evidence on this point.

We did not undertake a detailed analysis of the British, French or other systems of higher education. But at least one British science policy study speaks approvingly of the generalist nature of the U.S. undergraduate degree and against the specialization and rigidity of U.K. undergraduate science curricula.[12] Evidence available to us shows that French science programs have been structured along relatively rigid lines, but that the cries for reforms are now being heard.[13] And there is a general trend toward a reassessment of higher education and a willingness to consider reforms, as the following quotes from a 22-country survey illustrate (from

Australia to the U.S.S.R.) for the field of chemistry:

"Perhaps the clearest and the most obvious general trend is the growing tendency for chemistry curricula to come under closer and more critical scrutiny than in the past.... Degree of specialization and the nature of chemistry courses are coming under question.... There is a clearly discernible trend for non-specialist chemists.... There is in addition a feeling that specialist courses should also bring chemistry into closer contact with society and its problems.... Curriculums are being broadened ... teachers and course organizers are becoming much less dogmatic about what the specialist chemist ought to know...."[14]

And the same can be and has been said about physics programs in journal articles and at international conferences.

In reforming engineering education in the U.S. in the 1950s, the Massachusetts Institute of Technology (MIT) led the way. More recently, in 1970, a blue-ribbon committee of MIT faculty (joined by administrators and students) issued a report on curricula in the arts and sciences. In both areas, the report calls for major changes in the relatively inflexible freshmen and sophomore curricula, greater opportunities for individual study, and greater attention for the social consequences of science.

Toward a "Liberal" Science Education in Canada

The Faculty of Arts and Science at the University of Toronto recently introduced a "New Programme". The key passage from the calendar is worth quoting here:

"Each student ... devises his or her own programme by combining together each year five full courses chosen to fit the student's interest, subject only to ... prerequisite and corequisite requirements."[15]

The degree of specialization previously required in honours courses can be duplicated – but new specializations can also be formulated or the student can elect a highly flexible program. We understand that preliminary results are encouraging but that more time will be required before a complete assessment of the results can be made.

We wish to applaud and support these trends in and out of Canada. We are not saying that there should be less time devoted to the sciences, that there be no specialization, or that either rigour or contents be altered. Our argument can be summed up by saying that, like the architects of the University of Toronto "New Programme", we are in favour of making more of the courses elective rather than required, again subject to the prerequisite rules.

Encouragingly, there are indications that more and more university departments are now beginning to introduce more flexibility into their course programs. Our results indicate that a wider range of choice of course programs would be welcomed by students and employers alike.

More flexibility can be achieved in other ways, for example a combined honours program as at the University of British Columbia, in which students follow more than one specialization. Other possibilities are the introduction of more applied options in the honours program or the blurring of the distinction between the labels "honours" and "major". The precise means will vary with the situation in each institution. But given the traditional attraction and prestige of the honours program, the process of providing greater flexibility of choice in science curricula will naturally involve consideration of the honours program as an essential element.

In support of our argument, we refer to the previous section and then cite the following factors. First, several eminent scientists and educators stress the unity of science.[16, 17, 18] They also stress the threat of obsolescence to the young scientist. Next, they argue that at least some of our environmental and other problems may have come about, in part, because science and engineering graduates – whether from honours or general programs – failed to perceive the broader implications of their pursuits.[16, 17, 18, 19] Finally, some authors have called for more interchange of science graduates among industry, government, and educational institutions[20] and for increased emphasis on applied research. All of the above would make a science program with more flexibility and with more emphasis on social implications seem more attractive.

Secondly, even if we admit that the honours program in Canada leads to a professional degree and constitutes the ultimate in science education, several questions come to mind. Isn't graduate school a more appropriate place than the undergraduate program for specialization and concentration? Did those who chose the major sequence also go on to graduate schools with some success? Finally, just what becomes of the honours graduate?

The third and final argument in favour of more flexible science curricula comes from the responses of the graduates themselves. Our findings demonstrate a positive correlation between flexibility of education and subsequent job satisfaction. The major theme of the comments (which could be on any topic) was the need for a broader undergraduate education. Some respondents felt that the honours program prevented them from pursuing side interests which could have blossomed into their major interest.

Not all students who take an honours program, in a given field of science, eventually work or even want to work in that field. Internal and external factors force many graduates to make career changes – even shortly after graduation – which take them away from the field of primary study. Disadvantages concomitant with rigidity have been noted in other countries and in other disciplines. In sum, a flexible undergraduate education (obtained for example by those who had two "honours majors" or those in programs where electives occupied a relatively high share of the total time) shows a positive relationship to higher utilization and satisfaction levels in the work environment.

We are aware of the limitations of our study and the existence of counter-arguments. Thus, it would certainly be desirable to extend the discussion to:

1.) "Major" or "general" chemistry curricula;

2.) Graduates from the above programs;

3.) Course contents; and

4.) Successful and unsuccessful cases of educational reforms.

It is clear that pre-university backgrounds do make a difference and knowing these would help us make more valid – especially regional and international – comparisons.

It may be, though thought unlikely, that emphasis away from honours and toward major or general programs would produce "jacks-of-all-trades" who chose only the easy courses. Finally, it may well be that, to some extent, an honours education must often be rigid as it requires numerous prerequisites. As one educator stated: "One can go through the motions of having a permissive sequence, but it may be really meaningless, as the prerequisites make the rigorous education essentially quite rigid."[8]

Is the call for less specialization realistic? The academic rewards seem to favour those who specialize and "dig a hole" rather than "plough a field" of knowledge. The current system contains strong rewards and sanctions – recognition, grants and fellowships – which promote and reinforce a high degree of specialization. Moreover, for advanced graduate programs, a highly structured sequence of preparatory courses is often deemed to be necessary, leaving little room for flexibility of choice. But is the channelling and degree of specialization being undertaken too early in the educational process? A growing number of professors, students and industrial leaders seem to think so.

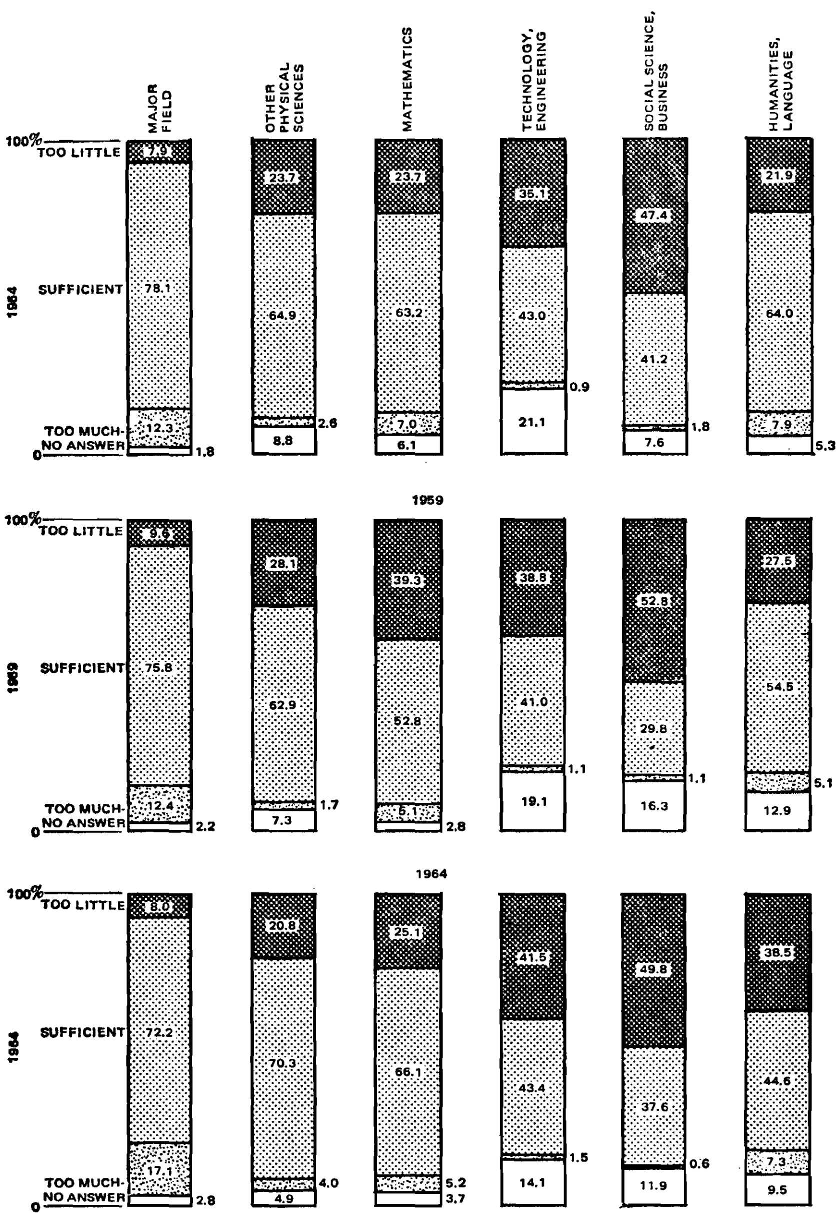
In sum, we would argue that the results and analysis presented here call for a re-evaluation of the honours programs in chemistry and physics at Canadian universities. If professors and department chairmen are willing to take a "second look" at the overall format of the honours sequence, we will have accomplished our purpose.

Sufficiency of the Undergraduate Curriculum

Respondents were asked to rate whether there was too much, too little, or sufficient coverage given to various subject areas in their undergraduate curricula. The results are shown in Figure III.1. There is relatively little difference among the three graduating classes. About three-fourths of each class rates the coverage given to the major field – whether it was chemistry, physics, or a combination of one of those with another field (e.g., physics and mathematics; biochemistry) – as sufficient. The corresponding figure for the sufficiency of physical sciences outside the major field is generally about 60 to 65 per cent. The ratings given to technical topics, the social sciences (which include business and management), and the humanities are decidedly lower, and hover in the 35 to 55 per cent range as a rule. By definition – and the respondents are aware of this – a physical science major and especially an honours program will give heavy emphasis to just one field. But the results shown here, coupled with numerous comments made by the graduates, reinforce the earlier recommendation that educators should reassess the course structure.

The information on the sufficiency of the undergraduate curriculum was related to the undergraduate major, native language, advanced degree status, and the current occupation of the respondent. In the first instance, the chemistry and chemistry-with-another-field majors were separated from

Figure III.1–Sufficiency of Undergraduate Curriculum, Classes of 1954, 1959 and 1964, BSc (Hon.)–Chemistry or Physics–Canadian Universities

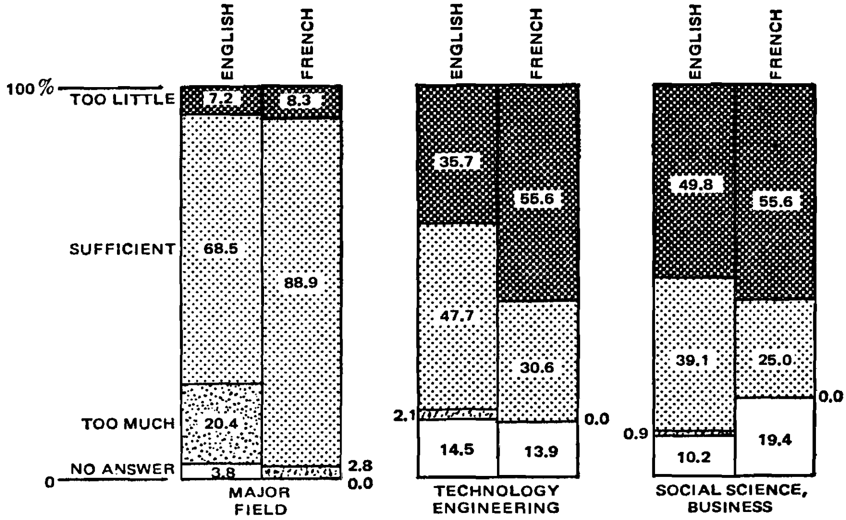


Source: Primary Survey.

the physics and physics-plus-another-field majors. The results (not shown here) indicate that the findings in Figure III.1 apply equally to either chemistry or to physics honours program graduates.

Contrasting opinions of English- and French-speaking graduates about the undergraduate program are given for the class of 1964, owing to small numbers of French-speaking graduates in 1954 and 1959 (Figure III.2).

Figure III.2–Sufficiency of the Undergraduate Curriculum English- and French-speaking Canadians, Class of 1964, BSc (Hon)–Chemistry or Physics–Canadian Universities



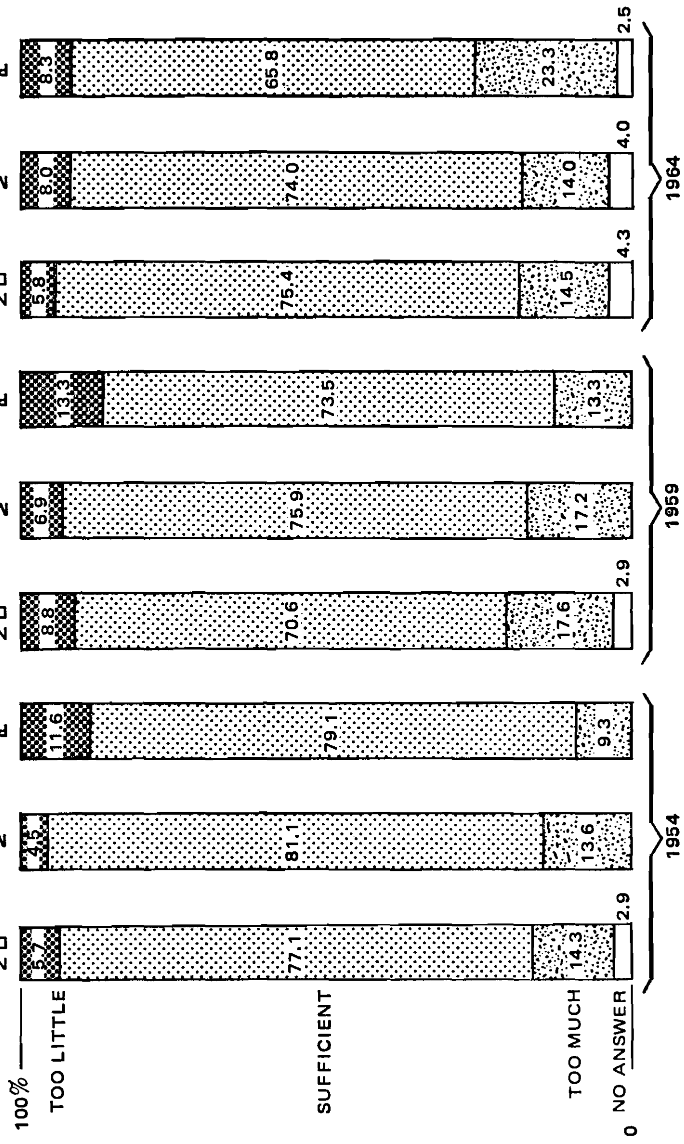
Source: Primary Survey.

Almost 90 per cent of the French-speaking graduates are satisfied with the coverage given to their major field, whether chemistry or physics, compared with less than 70 per cent of the English speakers. In contrast, the francophones are significantly less satisfied with the coverage given "applied" topics in the technical fields and social sciences. Coupled with data on curricula structure, we perceive that francophones merely want their programs to be more similar to those at English-language universities. As a result of recent changes in the educational system in Quebec, such a "homogenizing trend" is already in the making. This does not mean a homogenized education, but rather that the same broad trends are evident in university education in all parts of the country.

There is a tendency on the part of those who hold advanced degrees to be more charitable in their rating of the undergraduate program than those who have no such degrees. This appears to confirm the view that the honours program is pre-graduate school training (Figure III.3). Similarly, there are only minor variations in the "sufficiency ratings" given to the various undergraduate subject areas when the respondents are classified by major occupational categories. A notable exception is the social sciences and business subject areas, wherein the lack of adequate coverage is expressed strongly by those in all occupational categories, especially by those who entered managerial occupations (Figure III.4). Admittedly, one can squeeze only so much into a given curriculum or program, and one must rely on the students' desire for self-improvement. Still, the evidence indicates that the proportion devoted to social sciences and the humanities could be and should be increased (see Table III.1).

Professor Bruce McFarlane points out that this "lack" may also be due to the employers' demand for a certain background upon entry to

Figure III.3–Sufficiency of Coverage of Major Subjects in Undergraduate Major Curriculum by Educational Level Attained, Classes of 1954, 1959 and 1964, BSc (Hon)–Chemistry or Physics–Canadian Universities

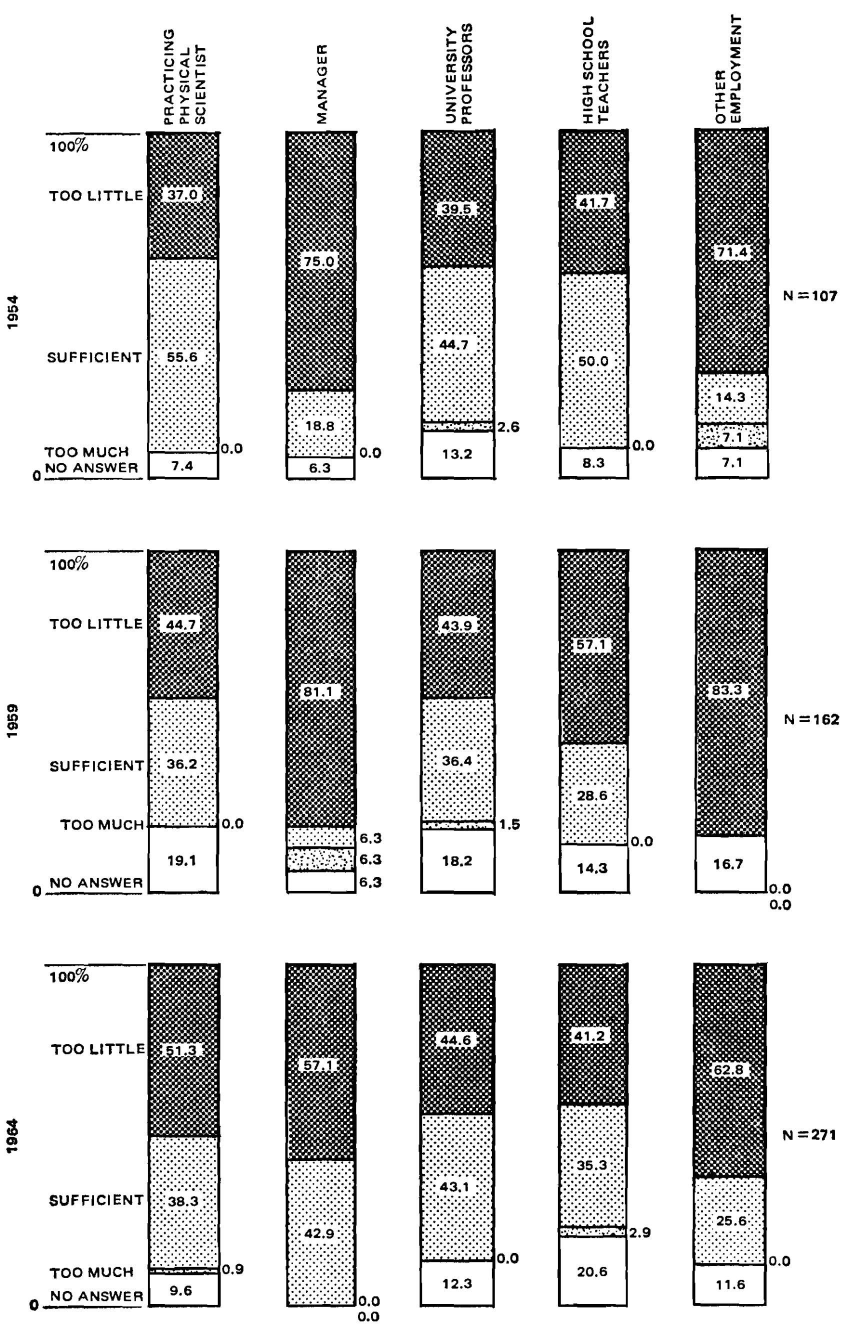


Source: Primary Survey.

industry followed by their demand for a different background after five years or so as employees move up the administrative rather than the technical ladder.[8]

In sum, the undergraduate honours program in chemistry or physics serves equally well (or equally poorly) those who become industrial or government scientists, professors, high school teachers, or those who are in other civilian occupations. However, the weakest link seems to be the

Figure III.4–Sufficiency of Coverage of Undergraduate Curriculum in Social Sciences and Business Subjects by Current Occupation (1970), Classes of 1954, 1959 and 1964, BSc (Hon.)–Chemistry or Physics–Canadian Universities



Source: Primary Survey.

lack of emphasis on the humanities, social sciences and business subjects. Those who felt the need most keenly for more education in these areas are holding senior managerial positions in the middle or latter part of their careers. A recent survey of educational levels of the most senior executives in the chemical industry by the Canadian Chemical Producers' Association reveals that about one-third have taken degrees in commerce or business administration in addition to technical or science degrees.[21]

Background of the Respondents

Characteristics

Our primary survey did not probe the family background of the respondents. We have, however, information from other studies on this and related aspects. Very briefly, young men and women who are enrolled in the faculties of (arts and) science come from a relatively high socio-economic background and exhibit a professional-independent attitude rather than a vocational-group orientation.[22] This is evident on a variety of scales, ranging from the parents' social and economic status to the students' own situation regarding summer work and graduate school (Table III.5).

Occupational Choice

The reasons for choosing a university major and a subsequent career can be many; for some students, there is no key reason (Tables A.6 to A.9 in Appendix A; see also Figure III.5 for the class of 1954). Consistent with findings about characteristics of physical scientists, they chose a major on the basis of challenge and interest first, inspiration by teachers in high school, second, and career considerations, third. Other factors received few votes; it is somewhat surprising that family is mentioned by only 2 out of 619 as influencing the choice of a major. This may reflect early assertions of independence, or it may indicate "inferential" family influence is higher than students are aware of, or willing to admit.

An interesting finding on the transmission of occupational choice is evident from the data in Table A.6. When the 1959 class is classified by current occupation, we find that those who entered high school teaching were largely inspired by their high school experience in their choice of a science major. Thus, the circle is complete: inspiration by a high school science teacher – selection of physical science – return to high school as a teacher, inspiring a new generation.

Managers are both *choosers* and *chosen.* For francophones, career considerations loom as a much more frequent reason for selecting a science major than is the case for English-speaking Canadians (Figure III.5). This is in line with the general trend of francophones being able to move (and wanting to move) into a variety of technical, scientific and managerial occupations, particularly in industry and government. For them, more so than for English-speaking graduates, scientific fields, particularly in industry, represent relatively new frontiers.

Academic Achievement

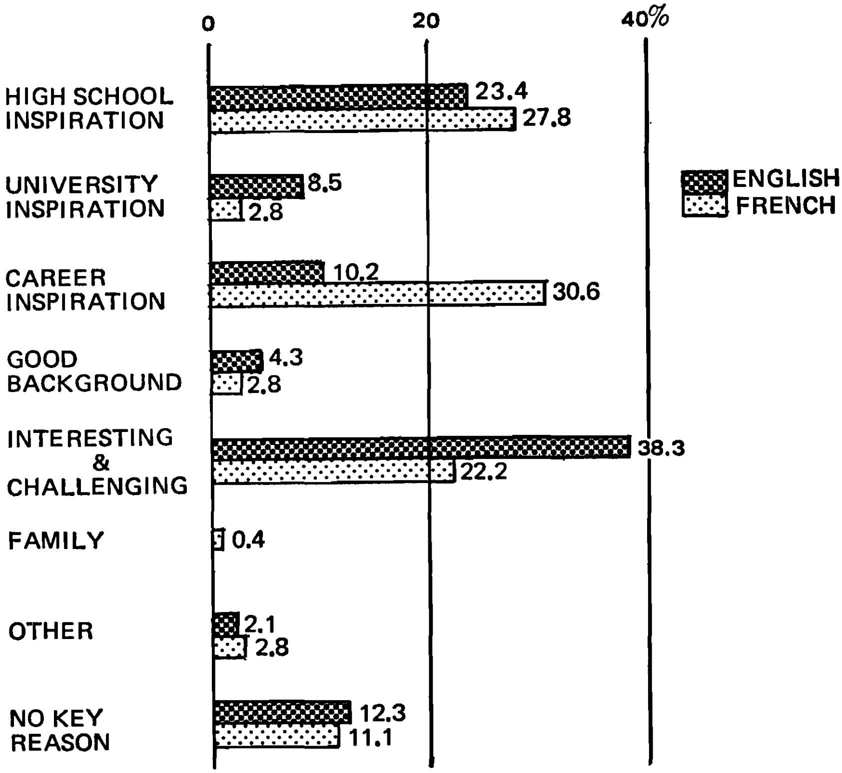
The respondents in our survey reported on their undergraduate academic

Table III.5–Selected Characteristics of Canadian University Students in Five Faculties, 1961-1962

Characteristic	Arts and Science		Education		Engineering		Law		Medicine	
	Male	Total	Male	Total	Male	Total	Male	Total	Male	Total
Age in median years	20.3		22.0			21.0		23.5		23.3
Per cent under 20 years of age	61.7		33.1		48.1			6.6		12.8
Single, living at home	47.0		24.9		41.4		39.1		35.0	
Single, living away	47.3		49.1		50.1		38.5		43.6	
Not single, living home or away	5.7		26.0		8.5		22.4		21.4	
From farms or >10 000 population towns		26.2		49.6		33.4		19.1		22.8
Per cent with fathers below high school graduation		50.5		68.1		57.9		48.7		50.7
Per cent with mothers below high school graduation		48.0		63.7		56.0		48.7		53.5
Per cent with parents' income >$6 000		45.6		67.4		59.3		40.8		46.3
Per cent with father's occupation as owner, manager, professional, commercial or financial		54.8		35.6		42.2		60.0		59.2
Per cent working summers for pay	85.0		70.0		94.0		91.0		93.0	
Per cent with summer job requiring skill	36.2		32.7		57.5		51.3		65.8	
Median summer salary per month	$233		$263		$274		$273		$242	
Per cent with interruption in education	13.1		33.4		13.4		16.9		8.5	
Per cent planning full-time graduate school		41.6		5.7		29.7	0.3		38.1	
Average expenditure for college, total	$1 395		$1 592		$1 533			$2 050		$2 246
Of above, education costs constitute	$ 512		$ 443		$ 610			$ 551		$ 802
Per cent receiving funds from parents		62.9		46.8		49.8		55.0		54.3
Per cent receiving funds from scholarship, bursary		26.9		38.5		39.3		33.2		41.9
Per cent of total income from parents		31.9		17.2		16.7		20.8		22.0
Per cent of total income from summer job		26.8		19.1		34.6		22.9		18.4
Average amount of bursary when received		$373		$396		$389		$327		$384

Source: Dominion Bureau of Statistics, *University Student Expenditure and Income in Canada, 1961-62, Part II: Canadian Undergraduate Students*, Queen's Printer, Ottawa, 1963. Tables 4, 6, 11, 14, 15, 16, 18, 21, 22, 31, 34, 44 and 47.

Figure III.5–Key Reason for Choosing Undergraduate Major, English- and French-speaking Graduates, Class of 1964, BSc (Hon)–Chemistry or Physics–Canadian Universities

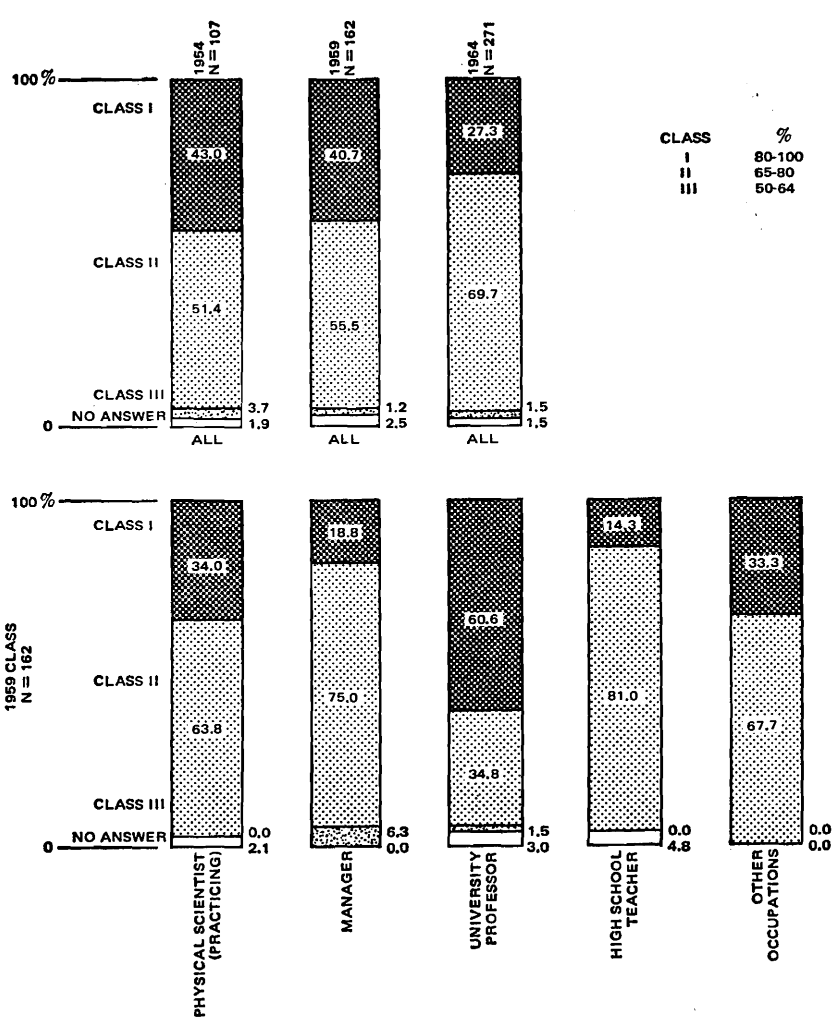


Source: Primary Survey.

performances: 43 per cent of the 1954 class received Class I honours, 41 per cent of the 1959 class and 27 per cent of the 1964 class (Figure III.6). These results are subject to a variety of interpretations and we leave it to educators to decide which explanation is correct. In the words of one chairman, "It is just as hard to train a real physicist now as it was twenty years ago." In fact, given the accumulation of new theory and practice, more has to be crammed into an honours program than was the case in 1950. This situation, coupled with rising enrolments, wider social selection of students, social pressure to attend college, the lure of well-paying science positions, and possibly stricter course standards may possibly account for the slide in performance.

When grades are analyzed by present occupations, a consistent and not unexpected pattern emerges. Those who are now professors (followed by practising physical scientists in industry and government), received significantly higher grades as undergraduates than did those who now hold posts as high school or grade school teachers, managers, or other civilian occupations. The former, of course, generally possess an advanced degree and what we see here is the usual selection procedure: those with better undergraduate grades are encouraged to enter graduate studies and to

Figure III.6–Undergraduate Grade Average By Year of Graduation and Present Occupation (1970), Classes of 1954, 1959 and 1964, BSc (Hon.)–Chemistry or Physics–Canadian Universities



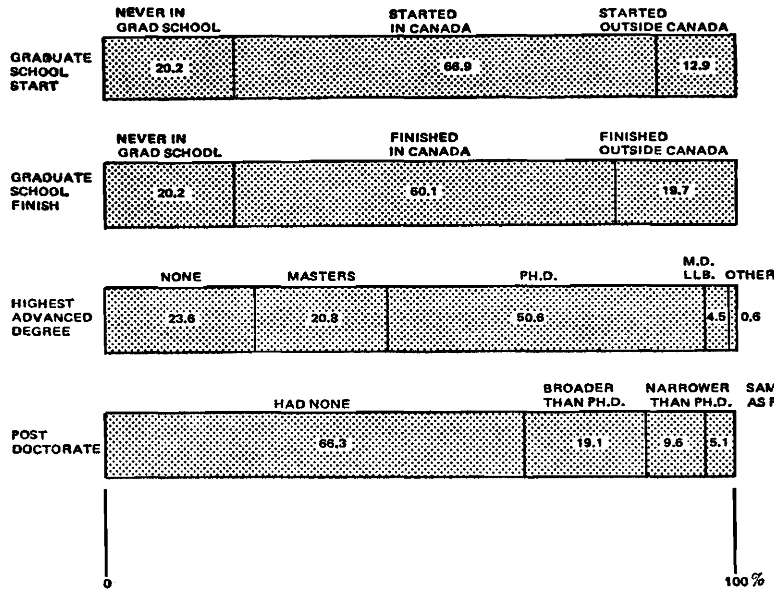
Source: Primary Survey.

pursue careers in universities or research departments. But changes in the labour market of the 1970s may alter this situation too.

Graduate Schooling

A high proportion of the respondents attended graduate school at some time, which illustrates the basis for the view that honours programs constitute preparation for advanced work in pursuit of master's and doctoral degrees. In fact, only one-fifth of our respondents never entered graduate school (Figure III.7). Of course, less than four-fifths of them hold advanced degrees, as some quit in midstream; still, a surprisingly large proportion did complete their graduate studies. Two-thirds of the 1954 class and three-fourths of the 1959 and 1964 class members hold a master's or

Figure III.7–Aspects of Education Beyond the Undergraduate Level, Class of 1959, BSc (Hon.)–Chemistry or Physics–Canadian Universities



Source: Primary Survey.

doctoral degree, and almost invariably it was earned in the physical sciences. Relatively few hold medical or legal diplomas (Table A.10). From 40 to 50 per cent of our respondents hold a PhD compared with only 27 per cent of all physical scientists in Canada.[23] These results indicate that honours graduates themselves decide and are chosen by professors to be the standard bearers for the profession.

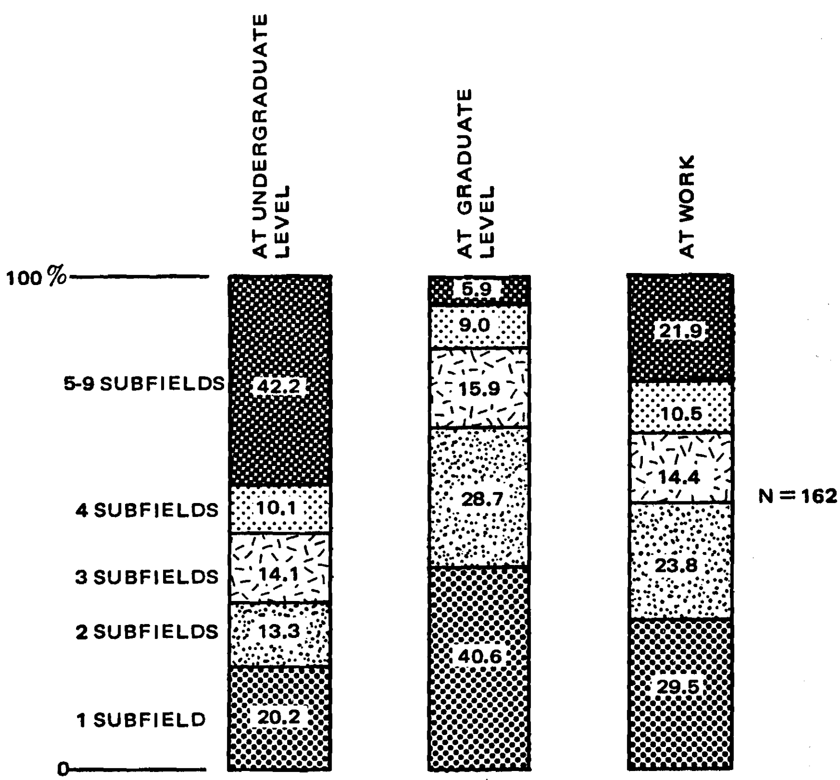
Of those who started graduate school only about 15 per cent did so outside Canada. In completing their advanced studies, however, from 25 to 33 per cent obtained their terminal degrees outside the country. The most frequent choice – in starting and finishing graduate work – was the United States; it was chosen by three times as many graduates as all other foreign countries combined (Figure III.13). However, there is evidence that with the rise in Canadian graduate schools, studying abroad – including that in the U.S. – has become less popular. It has also become more difficult in Canada to get funds for study outside the country. The Vietnam War and other considerations have probably also decreased the attractions of the U.S. for graduate students.

About one-fourth of all the respondents and over one-half of the PhD recipients held a post-doctoral fellowship at some time during their careers. Although the "post-doc" is believed to be of recent vintage, in fact the 1959 class members with PhDs held proportionately as many of such fellowships as those from the 1964 class (Table A.10). Most of the 1964 graduates would have received a PhD by 1968–70, before the full impact of the turndown in the job market. The use of the post-doctoral fellowship as a "holding operation" while looking for permanent jobs has become typical for some recent PhD graduates.[24] But the scope of the post-doctoral research tended to be broader than that conducted for the doctoral dissertation, which is a welcome trend, if we consider that the scope of the latter is usually narrow.

Subfields within the Major and in Graduate School

The question examined here was the extent of concentration among subfields (e.g., atomic, classical, or nuclear) within the major (physics), as respondents moved from undergrate to graduate education and on to jobs. The pattern is one of increasing concentration at the graduate level (Table A.11 and Figure III.8); one exception, as just noted, is the post-doctoral fellowship, but this can be viewed as work experience.

Figure III.8–Specialization in Subfields at the Undergraduate Level, Graduate Level and on the Job, Class of 1959, BSc (Hon.)–Chemistry or Physics–Canadian Universities



Source: Primary Survey.

The extent of switching among sub-fields is expressed in terms of similarity or "overlap" between those taken at the undergraduate or graduate levels and those which are used at work. In about one-half of the cases, there is no overlap between the undergraduate and graduate sub-fields. This indicates a broadening of science (honours) graduates' education and shows clearly that they have the potential to shift among a variety of sub-fields. (Table A.12).

Employment Patterns

Occupation, Industry and Function

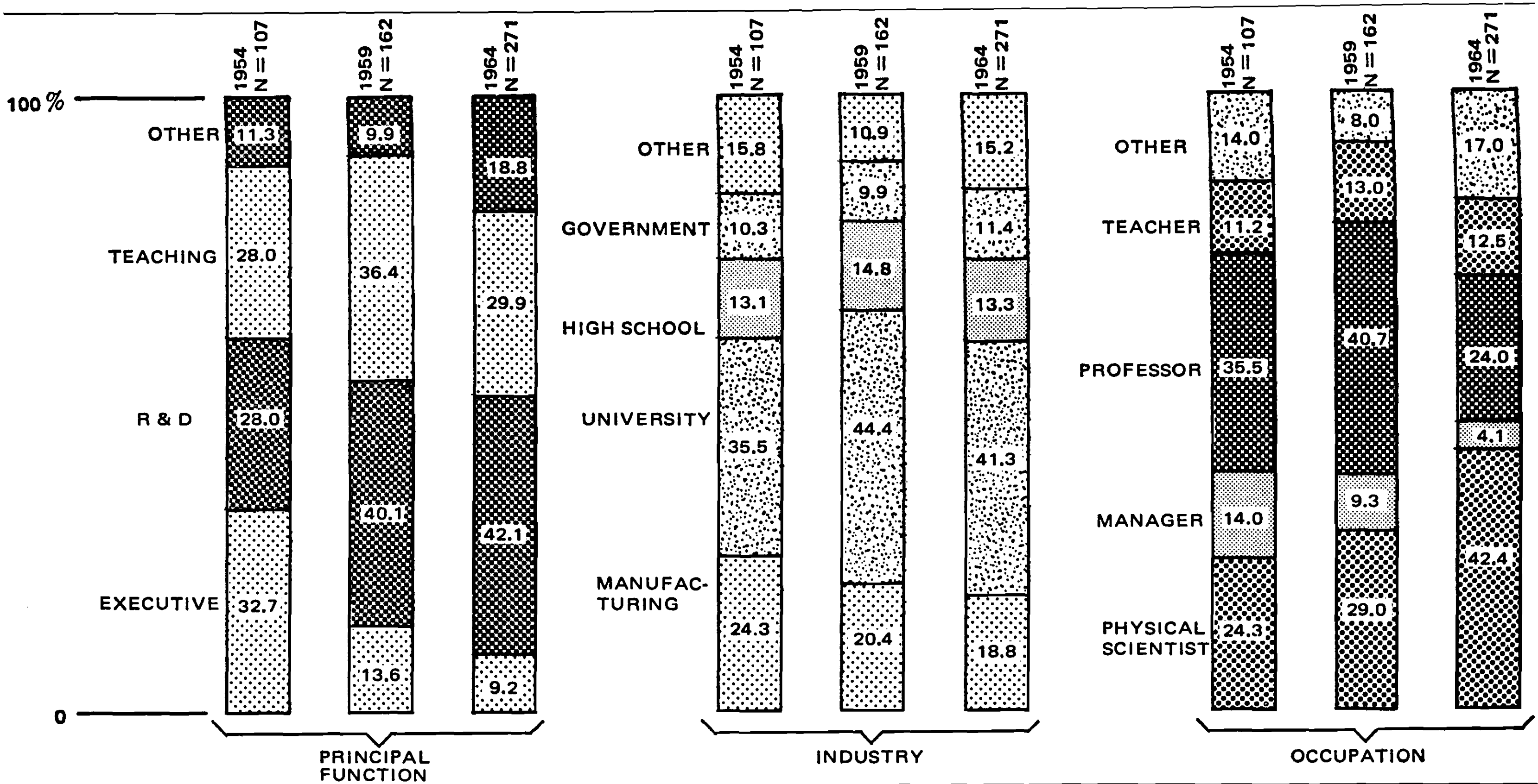
So far we have dealt with all 619 of the respondents. (A person's views regarding his education are important whether or not he is employed; it is also likely that he will be out of the labour force temporarily.) But we now turn our attention to those graduates who are working full-time. They total 540, specifically, 41 women and 499 men; 107 from the 1954 class, 162 from 1959, and 271 from 1964. Thus, about 7 per cent of the two earlier graduating classes and 17 per cent of the 1964 class are out of the labour force, 16, 11 and 6 years after graduation, respectively. In the case of the 1954 and 1959 classes, such persons are generally retired or housewives; in the case of the 1964 class, they are primarily graduate students. There were, respectively 1, 2 and 5 persons unemployed in the three groups; in each case, therefore, the unemployment rate is under 2 per cent. Nevertheless, widespread concern was expressed by the respondents about the labour market and the availability of jobs in the 1970s.

Figure III.9 and Table A.13 show the distribution of full-time workers by occupation, industry, and primary function. The overwhelming majority of the graduates in the survey – roughly three-fourths – entered one of three occupational categories: professor at a university or junior college; teacher at the high school level; or physical scientist working in the undergraduate field of specialization in industry, government, university, or an independent institute. The remaining fourth is distributed among a wide variety of occupations: managers, military officers, actuaries at insurance firms, doctors, lawyers, salesmen, and others. For the purposes of analysis this heterogeneous group was divided into two sub-categories: 1) managers and military officers (most of the latter 'manage') and 2) 'all other civilian occupations'.[25]

Paralleling this grouping by occupational categories is a grouping by industry and primary function. The obvious places of employment for professors, teachers and scientists are universities, high schools, and manufacturing plus government, respectively; their functions generally are teaching and research or development. But there are also some surprising results. Thus, for example, in the case of the 1954 class, about 47 per cent of the respondents classify themselves either as college or high school instructors; but only 28 per cent give their primary function as teaching. What happens is that for some educators, research becomes the primary function, while for others – at a university or in high school – administration becomes the key activity.

Examination of Figure III.9 shows that there are relatively minor variations in the occupational, industrial, and functional deployment of the three graduating classes. Differences (which approach, but do not reach statistical significance) reflect the length of time which members of each class have been in the labour force. Thus, many more of the 1954 group listed administration as a key activity than is the case for the other two

Figure III.9–Current Work Function, Industry and Occupation (1970) by Year of Graduation, Classes of 1954, 1959 and 1964, BSc (Hon.)–Chemistry or Physics–Canadian Universities

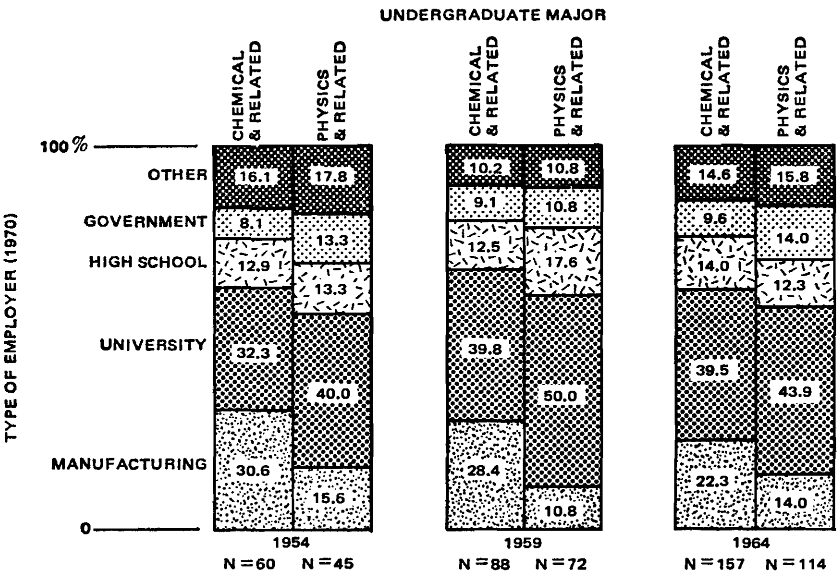


Source: Primary Survey.

classes. In a similar vein, more 1964 graduates work as post-doctoral fellows in universities than is the case for the two other groups, as they have not yet been admitted into professional ranks.

A significantly larger proportion of chemistry (and chemistry related) majors are employed in the primary and secondary sectors of the economy – essentially in manufacturing – than those whose honours program was in physics. This situation is illustrated in Figure III.10 and it is a reflection of the structure of the Canadian economy. Chemistry-based industries, led often by U.S. or U.K. subsidiaries have found that they can employ chemistry honours majors to advantage, although the opportunities – especially to do research – remain rather limited in those firms. In contrast to the 20 to 30 per cent share of chemistry graduates in manufacturing, only 10 to 15 per cent of the physics majors are in this sector. One thinks of Northern Electric, RCA, General Electric plus a few other large firms, and a handful of small companies which serve as the main potential industrial base for the employment of physicists.

Figure III.10–Type of Employer, by Undergraduate Major, Classes of 1954, 1959 and 1964, BSc (Hon.)–Chemistry or Physics–Canadian Universities



Source: Primary Survey.

Comparing the deployment of English- and French-speaking graduates (Table A.14), we find no significant differences in their employment patterns, with the near-exception of those in professorial ranks. Thus, 33 per cent of the francophones and only 23 per cent of the anglophones in the class of 1964 teach at the university level. (About the same ratio holds for the 1959 class, but the size of the French-speaking sample is too small for consideration.) This is attributable to the more rapid expansion of higher education in Quebec than elsewhere and specifically to the fast growth of French-language junior colleges. As this process is completed – and there are indications that across Canada enrolments are rising more slowly – opportunities in higher education will be more limited for new graduates, French- or English-speaking.[26]

The expected, significant differences emerge when we investigate the industrial distribution of the respondents by advanced degree status. Those who hold only a bachelor's degree seldom find professorial positions, while the reverse is true for those holding higher degrees (Table A.15). It is, however, not unusual to find, in the case of the 1954 and 1959 classes, the occasional full professor with a bachelor's or master's degree. The insistence on the PhD as the terminal degree for university-level teaching (though not necessarily for research done at universities) it quite clear. It may be desirable, in the light of this, to relax academic rules, in order to attract industrial scientists into higher education (for short or long terms).

Job Offers

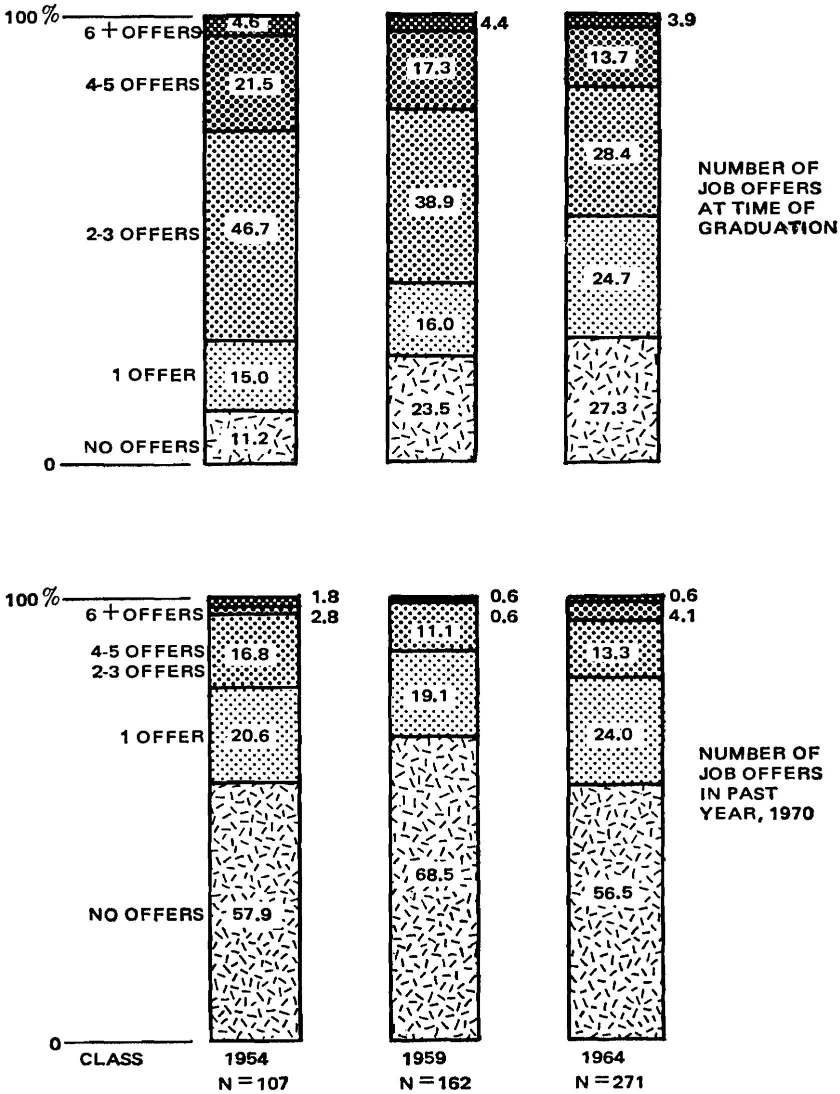
The number of job offers received by the respondents at the time of graduation and in the past year is indicative of the strength of the labour market, the lure of graduate schools, and the perseverence of graduates. As Figure III.11 shows, there are significant differences among the three classes. But the variations reflect less the business conditions prevailing (at time of graduation *or* in the past 12 months) and more the individual decisions to enter or not to enter graduate schooling immediately after obtaining the BSc or BA. The 1959 and 1964 class members were more apt than their 1954 counterparts to continue their studies uninterrupted, as graduate schooling had become even more popular and financially available by then for honours graduates. We consider the number of job offers extended to the respondents as quite satisfactory. The information on extent of unemployment between jobs further confirms that in autumn 1970 the graduates in the survey did not face – except in a very few cases – a situation wherein they would have to search for long to find a position.

Mobility

The current deployment of the graduates is but a single picture, hiding much mobility in previous years. Tables A.16, and A.17 in Appendix A and Figure III.12 rectify this situation, showing the occupational distribution of the respondents at selected times and the type of job shifts which they have experienced. The industrial and functional distributions, by and large, tend to parallel the occupational pattern; one must recall, however, that a physical scientist may be employed in an industry, a university or a government agency. (Manufacturing and government, over the years, have traditionally claimed about 22 and 10 per cent, respectively, of all graduates, regardless of year of graduation as seen in Figure III.9.)

Figure III.12 shows the occupational distribution of the respondents by class at selected times, at about 5, 10 and 15 years after graduation. The most striking feature is the absence of 60 per cent of the respondents from the labour force in the September following graduation, and in this respect the three classes are quite comparable. However, the majority graduated before the full impact of the poorer job market in the early 1970s could be

Figure III.11–Job Offers at Time of Graduation and During the Past Year (1970), Classes of 1954, 1959 and 1964, BSc (Hon.)–Chemistry or Physics–Canadian Universities

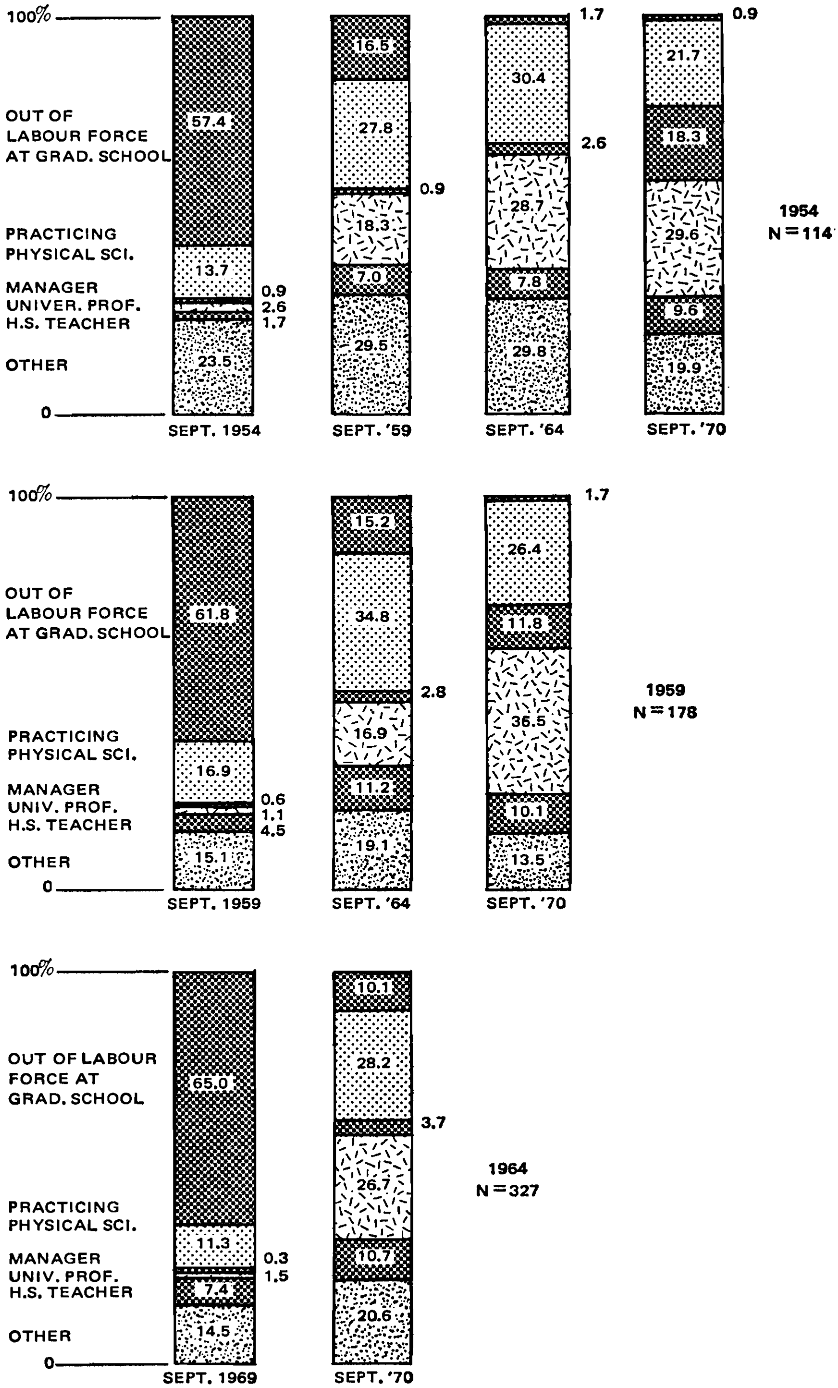


Source: Primary Survey.

felt. Five years after their graduation we still find 10 to 15 per cent of the respondents pursuing advanced degrees on a full-time basis. Nevertheless, the charge which one hears about graduate schooling increasingly becoming a haven for those who do not want to join the labour force is *not* borne out by the statistics. There is no tendency to linger and there is no evidence that it takes longer now to obtain the doctorate.

As graduate schooling is completed, occupational distribution takes on a more familiar look. The proportion holding jobs as physical scientists

Figure III.12–Occupational Distribution at Selected Intervals Between 1954 and 1970, BSc (Hon)–Chemistry or Physics–Canadian Universities



Source: Primary Survey.

rises in the first decade, but declines afterward. Five and ten years after graduation, a movement to professorial and managerial ranks can be observed. The identical trends for all three classes confirm that the patterns observed are traditional and have remained stable so far. But there are strong forces at work which will limit the number of professorial and industrial scientist positions in the 1970s.[27] Thus, occupations in such fields as high school teaching, industrial consulting, or pollution control will probably be sought by an increasing share of science graduates, including those from honours programs. While much of the adjustment may come at university entry levels when a career is originally chosen, we must also face the situation of physical scientists retraining themselves in mid-careers.

Table A.17 shows the numbers and types of job shifts which the graduates have experienced. In the 1954, 1959 and 1964 classes about 30, 43, and 56 per cent, respectively, made no job changes. Mobility has been experienced by more than half the respondents; in several cases, people have changed jobs three or more times. Furthermore, complex job changes, those involving a change in employer-industry and occupation, have been most frequent. The second most popular job change, admittedly, is a shift among employers only, retaining the same occupation and industry. It appears, therefore, that there is a strong tendency either to continue in the same line of work or to make a major change in career development. There is still another alternative, namely an occupational change *within* a given firm or industry. In large companies, especially, this is not an unusual step as research scientists are promoted to R & D management.

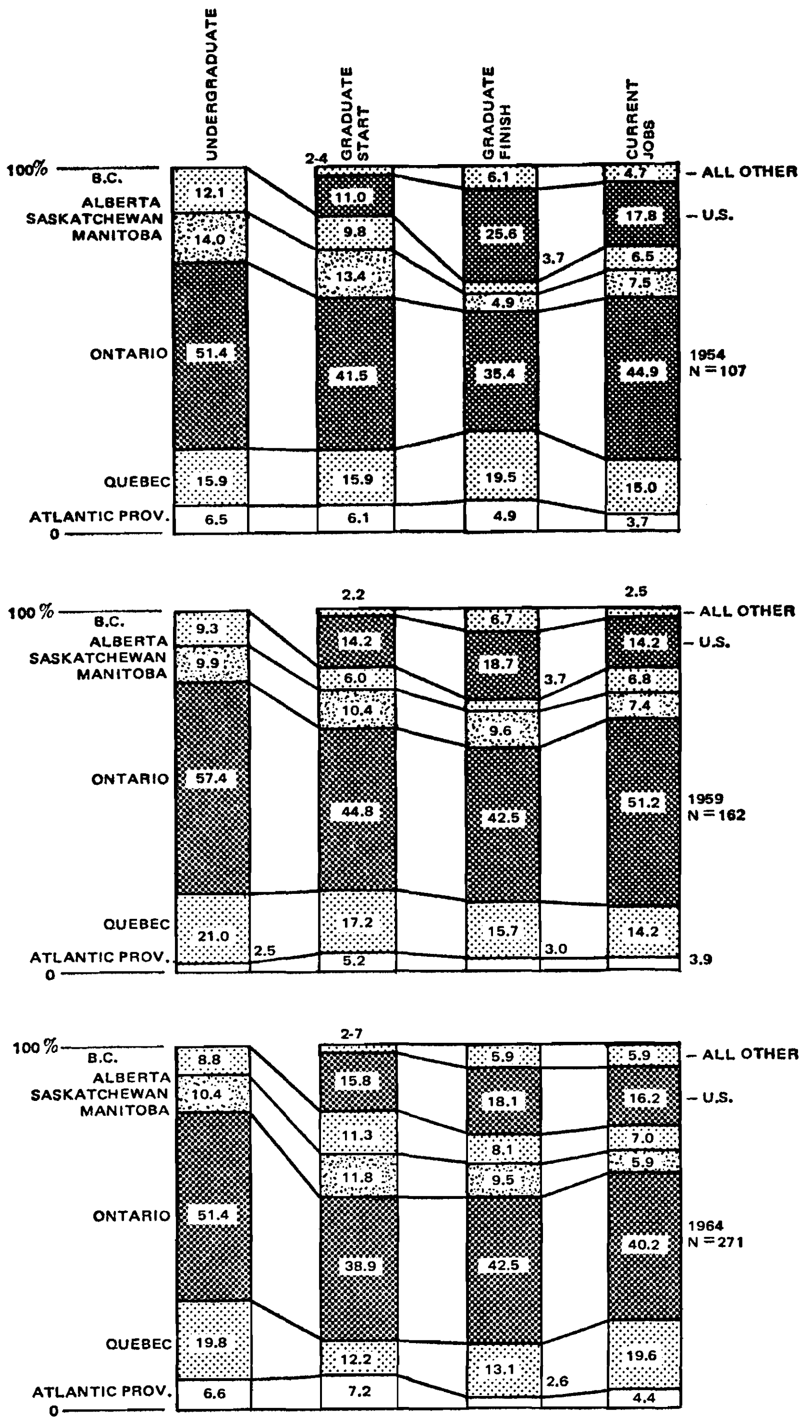
When we take into account the total amount of years the graduates could have spent in the labour force had they worked since obtaining the bachelor's degree (that is, about 16, 11, and 6 years, respectively for the 1954, 1959 and 1964 classes) and compare this with the amount of mobility they experienced, we find no differences in the job shifting patterns. That is to say, perhaps contrary to popular opinion, recent graduates are not more likely to job hop than those who finished in the 1950s.

The geographical mobility of our respondents is traced in Figure III.13. We see generally a decline in the concentration of the respondents in Ontario; the other provinces also lose proportionally even more graduates. This occurs because from 14 to 18 per cent of each class found employment in the U.S. while from 3 to 6 per cent located jobs outside North America. If we were to adjust the figures and concern ourselves only with Canadian residents, then the pattern emerging differs little from the geographical distribution during the undergraduate years. In view of scientists' concentration and movement to Ontario, as evidenced by the 1967 Manpower and Immigration Survey referred to in the previous chapter, this must be viewed as a counter-trend, reflecting increased job opportunities for graduates in a number of provinces.

Earnings

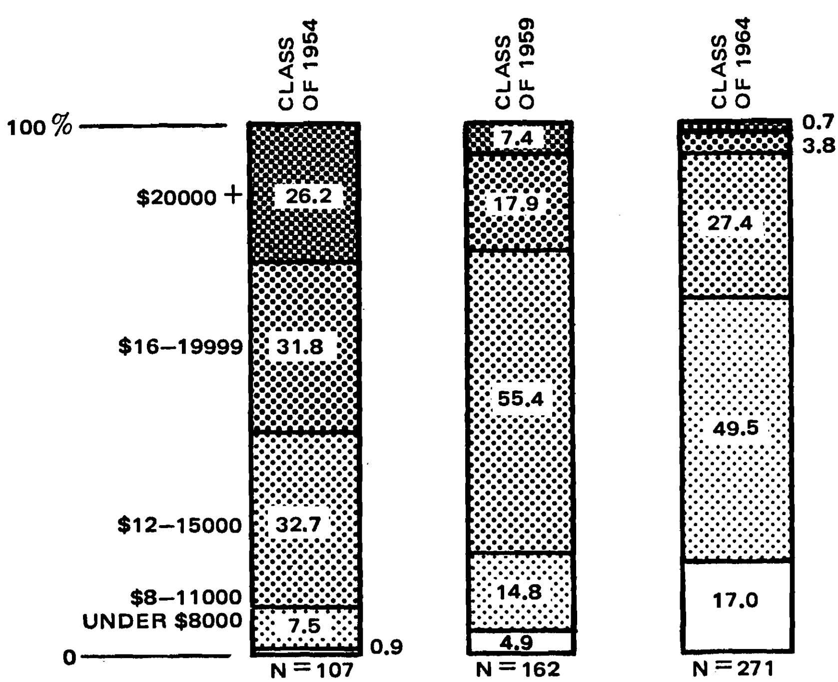
The data in Figure III.14, in Appendix D and other information not shown all indicate that science graduates reach a relatively high level of earnings, particularly later in their careers. Other studies confirm these results.[28] For example, one-quarter of the 1954 graduates earned above $20 000 per year

Figure III.13–Geographical Location of Undergraduate Studies, Graduate Studies and Current Job (1970), Classes of 1954, 1959 and 1964, BSc (Hon.)–Chemistry or Physics–Canadian Universities



Note: All undergraduate studies were done in Canada.
Source: Primary Survey.

Figure III.14–Current Annual Salary (1970), Classes of 1954, 1959 and 1964, BSc (Hon.)–Chemistry or Physics–Canadian Universities



Source: Primary Survey.

in 1970. Mean or even median earnings of our science graduates compare favourably with corresponding averages for Canadian wage-earners as a whole. There is a wide range of incomes in our sample, just as there is for the labour force. What factors explain the variation within our sample?

The following variables showed significant, positive correlation with annual income in the case of all three graduating classes: geographical location, industrial affiliation, satisfaction with the work environment, and professional activity. Thus, for comparative positions salaries were higher in the U.S. than in Canada, higher in industry than in government or academia – results which might be expected. Being professionally active and satisfied with one's work situation accompanied rather than substituted for high salaries. (Thus, one might say: attend conferences, read journals, publish and prosper.) On the other hand, possession of an advanced degree, high grades, consulting work, and some other factors, while positively related to earnings, generally did not make a significant contribution.

The importance of industry does not mean that professors always earn less than physical scientists in industry, because other factors are seldom equal. The professor may possess qualifications (e.g., good publishing record, some administrative ability, consulting experience) which, combined, can offset the fact that he or she is not employed in a profit-making sector of the economy. Considering an individual with a given background and qualifications, however, it is certainly more lucrative to undertake a given assignment, such as research, in an industrial rather than in a government or educational setting.

Utilization Patterns: The Education-Job Interface

We attempted to assess utilization of science graduates in a variety of ways: 1) usefulness of specific education for the job, 2) degree a prerequisite for the job, 3) satisfaction with the work environment, 4) the extent to which persons with a different background could do the same job, and 5) "second thoughts." In other words, we attempted to go well beyond an examination of labour force status or functional activity when analyzing the topic of utilization.

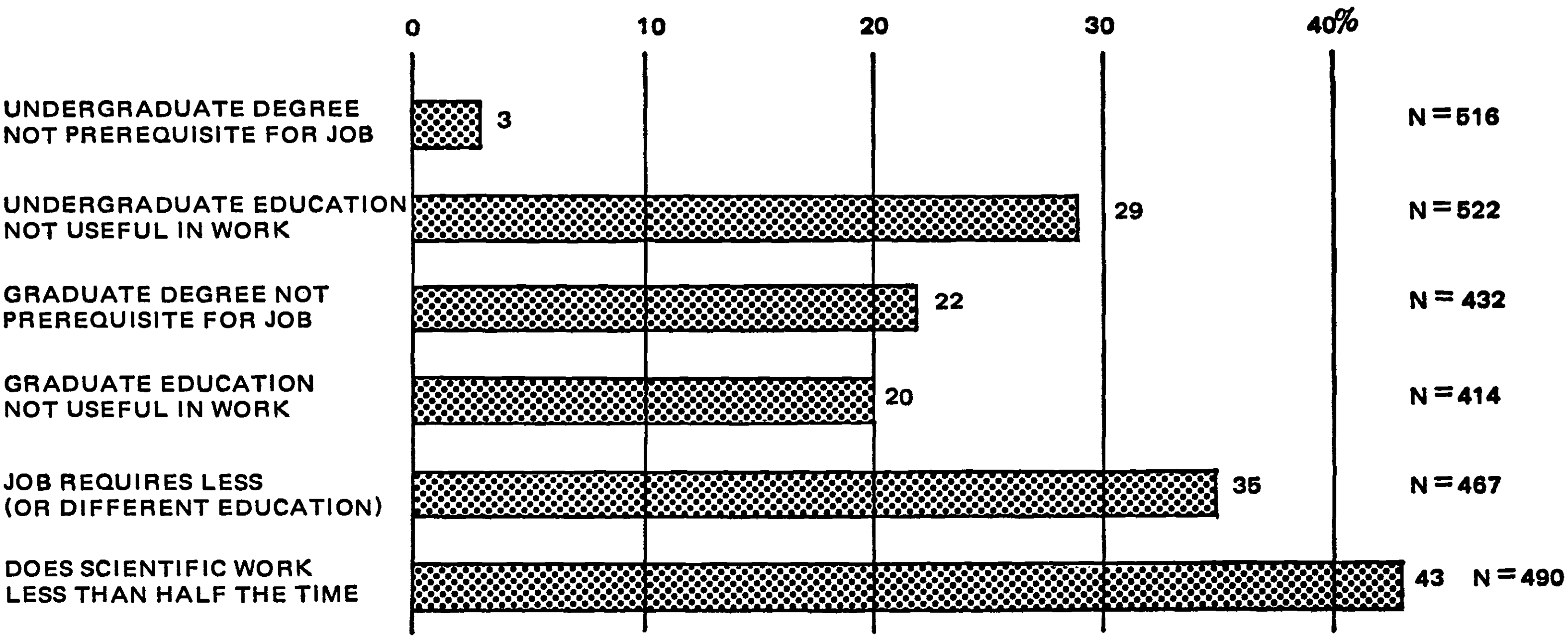
Utilization of Education on the Job

The extent to which the respondents consider their undergraduate education useful and necessary to their jobs is shown in Figure III.15 and Table A.18. There are no significant differences among the classes. About 60 per cent of each class states that "considerable use" is being made of the undergraduate training in carrying out their present tasks. Slightly less than 40 per cent of all three groups view an undergraduate degree in their field as a prerequisite for the job they are doing. Remarkably, almost as many feel that an undergraduate degree in a closely related field would also be acceptable. Thus almost 80 per cent of all three groups view their honours program *or* education in a related field as a prerequisite to their work. Furthermore, almost one-fourth make little use of the undergraduate major ("occasional use," "no use," and "college generally useful"). These results, along with other findings and remarks, indicate that the physical science curriculum in general is viewed as both necessary and useful for subsequent work assignments. The courses – whether physics, mathematics or chemistry – were useful preparation for many professions. But the specific major and honours nature of the program are rated as of secondary importance for present tasks.

The large difference between those who thought that the undergraduate degree was useful as a prerequisite to enter an occupation, 97 per cent, and the proportion who found it useful on the job, only 80 per cent, may mean that the degree is used to some extent as a device to screen people for entry into jobs which do not require a university degree. But a significant proportion, almost two out of three, can be found in jobs which they think utilize their present level of education. About 40 per cent are doing scientific work less than half of the time. This ratio of education to job correspondence probably represents a peak, at least in comparison with similar studies of Canadian engineers.[29] Among the latter, many left engineering for management.

There can be little doubt that the high demand for highly qualified manpower in the last decade has favoured the possibility of science graduates obtaining a job closely matched to their education. This process has also been aided by the expansion of science-based industrial firms. The relevant question is, however: will future graduates be as successful in matching education and jobs as their counterparts in the 1950s and 1960s?

Figure III.15–Relevance of Specialized Undergraduate or Graduate Education to Employment, Classes of 1954, 1959 and 1964, BSc (Hon.)–Chemistry or Physics–Canadian Universities



Source: Primary Survey.

If the answer is "probably not," it re-inforces the importance of a re-examination of the relevance of specialized university educational programs in relation to subsequent employment.

Some department chairmen have been critical of the view that physical science honours programs may have been too structured in the 1960s. They say:

"Looking at purely the headings and calling this chemistry or physics really doesn't *mean* anything as I think any competent scientist will tell you today. Much of what is taught in chemistry is physics, and some of what is taught in physics could justifiably be called chemistry. Physicists have shown great versatility in moving into areas outside their immediate specialty. At the present time honours physicists are welcome into graduate departments of meteorology, oceanography, biophysics, and many others".[8]

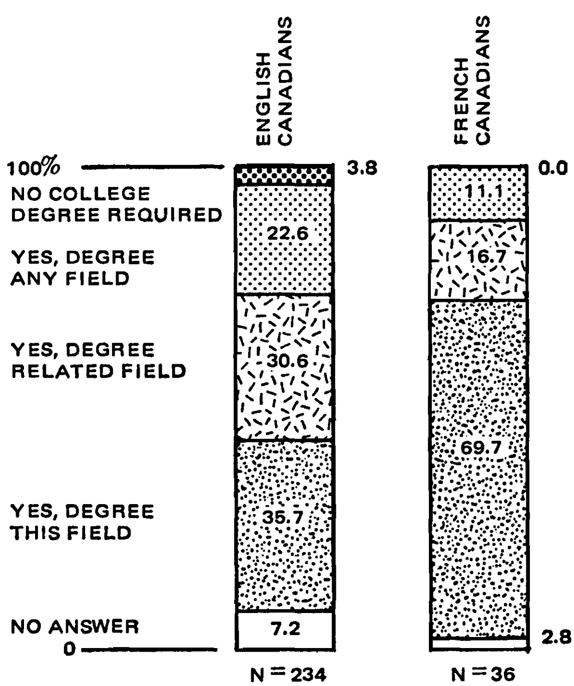
But this is precisely our and – more important – the graduates' point of view and in effect destroys the defence of a structured honours program.

We have shown that honours graduates enter a variety of specialties, in diverse organizational and institutional settings. The evidence here tells us that it is the science program, not the specific major or courses, which is useful and necessary for the world of work. In sum, the arguments are rather strongly in favour of a more flexible curriculum in terms of structure, fewer required courses in a major, more cross-fertilization, and even the reconsideration of the existence of majors within physical science. An obstacle remains in that chairmen and professors like to expand their own discipline and department, and to train young men for academic pursuits. Along these lines it is appropriate to note that the bachelors of engineering produced by some universities now have no designation as to field.

In further analyzing the science undergraduate program as a preparation for the world of work we note that there is a difference between English- and French-speaking graduates on the necessity question (Figure III.16). Thus, almost three-fourths of the latter view their undergraduate education as a prerequisite for their current work as against half that figure for anglophones. We attribute this to the fact that, due to past shortages of qualified French-Canadian scientists and recent expansion in the higher education system of Quebec, francophone scientists have found it relatively easy to find jobs which matched their education.

Examining the necessity and usefulness of undergraduate education by advanced degree status does reveal some interesting results. In Figure III.17 we compared those who have no degree beyond the bachelor's with those who do and then subdivided the latter group into master's and doctoral degree holders. There are no significant differences on the necessity question, but on the usefulness aspect, the advanced degree holders report significantly higher levels of utilization. PhDs report still higher levels than MScs. Finally, when the analysis is extended to occupations, both on the necessity and especially the usefulness questions (as Table A.19 shows for the 1959 class), professors report the highest utilization levels, followed by high-school teachers and industrial scientists. A significantly high proportion of those in managerial occupations – not surprisingly – report little

Figure III.16–Utilization of Undergraduate Education on the Job: French- and English-speaking Graduates, Class of 1964, BSc (Hon)–Chemistry or Physics–Canadian Universities



Source: Primary Survey.

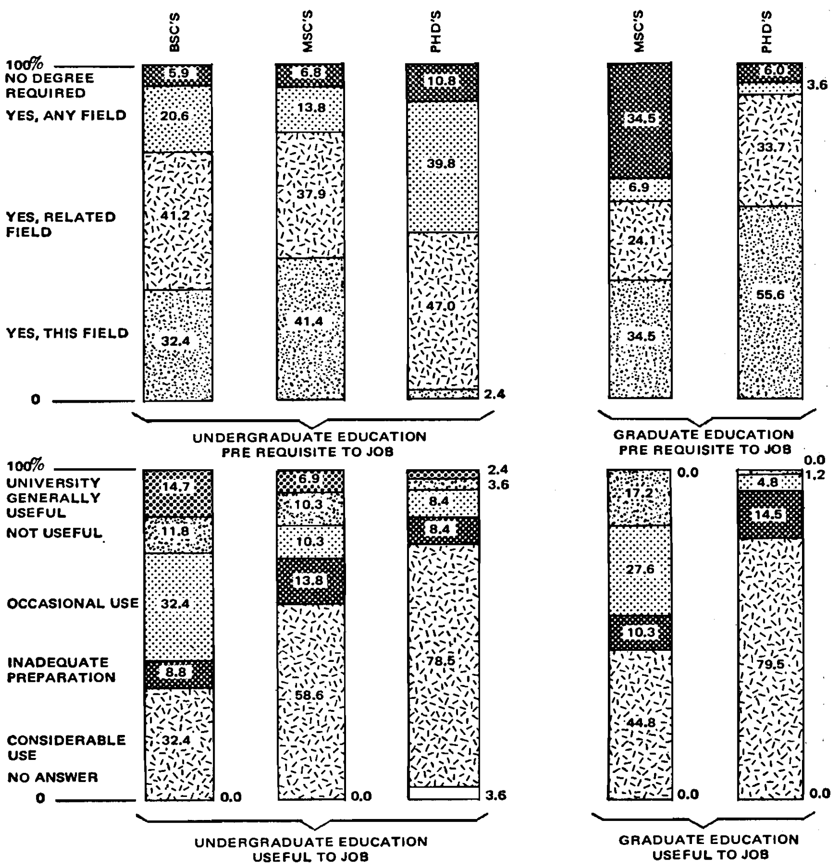
use being made of their education on the job.

All of the above findings confirm the traditional view that the honours program is designed for advanced studies and university-level teaching or research in the sciences. Chairmen wrote to us approvingly of honours programs as ones which "train physicists (or chemists) in the true sense of the word – people who have a solid foundation and who are going to do graduate work". Furthermore, they asserted that

"... other programs, majors or 'general streams', 1) are oriented toward 'relevant' or 'applied' aspects 2) provide greater degree of choice for and make less demand on the student, and 3) are designed as 'outlets' for those who go into high-school teaching, community college teaching, industry and government service."[8]

The fact remains, however, based on statistics already shown in Figures III.9 and III.12, that only about one-third of the honours program graduates surveyed teach and do research as professors. From one-quarter to one-third of the respondents hold no degree beyond the BSc (Hon.). In short, the majority are not the future generation of university professors or campus-based scientists and any program designed to perpetuate that scheme is not realistic or desirable. Indeed, the problem will be greater in the 1970s as enrolment growth levels off and openings at universities and

Figure III.17–Selected Aspects of Utilization of Education on the Job, Class of 1959, BSc (Hon.) –Chemistry or Physics–Canadian Universities



Source: Primary Survey.

colleges – whether for PhDs or MScs – become scarcer.

If the honours program is to be retained, its advocates must face the fact that the graduates from this stream will enter a variety of industrial and functional settings. This implies that the "stream" producing these men and women is in need of reassessment, and that educators must perform this task in the near future.

Considering now graduate education, we turn to the statistics presented in Figures III.15 and III.17 on education beyond the bachelor's degree. On being asked about the usefulness of specialized education, 80 per cent at the graduate against 71 per cent at the undergraduate level answered that they need or make "considerable use" of the field (major) taken at those levels. These differences are not statistically significant, but they suggest that graduate education rates equally with or slightly more than its undergraduate counterpart, when it comes to the matter of the utilization of education in the performance of the work.

However, when we divide graduate degree holders into two groups, those holding MScs and PhDs, we pinpoint a difference which is significant. On both the necessity and the usefulness question the PhDs score substantially higher than do the MScs. In fact, the MScs rate their advanced training in a less favourable light than they do their undergraduate education. We surmise that the material obtained at the master's level may have represented little more than a recapitulation of the undergraduate years and that the findings reflect this disappointment. The thrust of graduate education comes at the doctoral level and it is this program which is recognized by employers and which proves to be a prerequisite to job finding and job holding (especially in academia) and of considerable use in performing the various assignments.

Ease of Substitution

There is another way of assessing utilization of college education in the work environment. This is to ascertain the extent to which persons with different backgrounds than the respondent could perform the same task. Due to the constraints of our survey, we ascertained this in a highly subjective manner, by asking the graduates whether or not differently qualified individuals could do their tasks quite adequately, less efficiently, or completely inadequately. The answers are tabulated in Table A.20 in Appendix A and Table III.6. Once again, there is good agreement among the three graduating classes, so the conclusions drawn apply equally well to all of them. In response to the general question, "Could your job be done as well or better by someone with an education background different from yours?", fully 55 to 60 per cent responded with a "no". Approximately 15 to 20 per cent state that someone with training in a different field – at an equally high level – could do the job. From 10 to 15 per cent state that a person with less formal training could carry out the current job assignments and about the same proportion state that none of the above answers fits their situation. These findings can be interpreted in a variety of ways. Thus, one could say that in the majority of situations, the education and job profiles are well matched. But it is equally true that for a substantial minority, a different (or even a lower level) education would suffice.

To throw further light on the topic let us look at possible subsitutions in terms of specific alternatives (Table A.20). There is a general agreement among classes on the way they rate possible substitutions. The results are in line with what might be expected, although there are a few surprises. Ranking lowest on the 'ease of substitution ladder' are university graduates

Table III.6–Ease of Substitution by Those with Different Kinds of Education, Classes of 1954, 1959 and 1964, BSc (Hon.)–Chemistry or Physics–Canadian Universities

Could Job Be Done By Others?	Percentages		
	1954 (n=107)	1959 (n=162)	1964 (n=271)
No	53.3	61.7	53.5
Yes, with training in other fields	21.5	16.0	15.1
Yes, with less formal education	14.0	9.3	15.5
Yes, with only technical training	0.9	0.0	0.7
None of the above fits; no answer	10.2	12.9	15.1
Total	**100.0**	**100.0**	**100.0**

Source: Primary research by the authors.

with training in the humanities, technicians with community college type training and possessors of BCom degrees, i.e., business administration/commerce graduates. Less than 10 and often less than 5 per cent of our respondents think that such persons could adequately carry out their present tasks. Next in line are those with MA or MBA degrees along with PhDs in the humanities or management. Even an advanced degree in these fields is thought to be ill-suited for tasks normally carried out by science graduates.

But surprisingly, engineers rank quite highly. In fact (Table A.20), holders of BEng degrees do as well as BScs from different fields. We attribute this to the heavy scientific orientation of recent engineering curricula. The Canadian engineering curriculum has not become as scientific as its U.S. counterpart, but it did become significantly broader and less rigid.[30]

In an age when it is both fashionable and desirable to speak of such new fields as bioengineering, it is equally proper to view the sub-fields of physical science in a closer relationship to each other. In fact, we begin to see a "bridging of the gap" at the graduate level – note the relatively high scores given on the substitution question to MScs and PhDs from a different field of physical science. In other words, a chemistry major in graduate school can ill afford to neglect key aspects of, say, physics and biology. There is evidence of such trends even at the undergraduate level; witness the "New Programme" of the University of Toronto, the double options of the honours program at the University of British Columbia and similar changes. There is still further room for such improvement.

Satisfaction with the Work Environment

We have probed our graduates' view of their work environment using 11 questions to which numerical answers were sought on a rating scale. The results, shown in Tables A.21 and A.22, indicate that most graduates are moderately satisfied with the work environment. Admittedly, we have combined several aspects of the job in a given question; for example, the first one refers to job conditions, colleagues, etc., while the second encompasses prestige, promotion and salary. Nevertheless, each question attempted to probe one specific aspect of the work environment.

There are, despite the strong "central tendency", some notable, though often not statistically significant differences on the various questions. Not surprisingly, the lowest score is given on the extent to which administrative and managerial planning aspects enter into the respondents' world; in fact, few of our graduates are engaged wholly in non-scientific pursuits. The next lowest score is registered on whether the work is "socially useful and involves dealing directly with people". This is a notable phenomenon, given the share of respondents in teaching (and research) functions in universities and high schools. Incidentally, the scores for high school teachers are higher than for professors. Those who observe that honour students want to be (university) academics might interpret these responses by high school teachers as a rationalization for "failure". Or could it be that the generation and transmission of knowledge as expressed via research and teaching at universities are not seen as socially useful or dealing with people? The respondents' comments indicate that this impression exists especially in, but also outside, higher educational institutions. This lends support to the view of many that universities should consider "reorienting their priorities" toward more socially useful ends.

The remaining eight questions receive generally average or slightly above-average scores (i.e., near 80). The topics range from aspects of the work environment related to salary, working conditions and colleagues, opportunities for advancement, freedom and variety of job assignments, to self-confidence in carrying out such tasks. There are no statistically significant differences among the three classes, though the older graduates consistently show a slight edge on all questions. Working conditions in general (including relationships with colleagues, freedom in job assignments) and self-confidence in scientific assignments rank highest. Somewhat surprisingly, self-confidence to carry out administrative tasks is also rated high. Compared to the low scores recorded on the actual administrative content of the job, these results seem to imply that science graduates see themselves as competent to manage their present tasks. That they should do so has been advocated by others and our results point in the same direction.

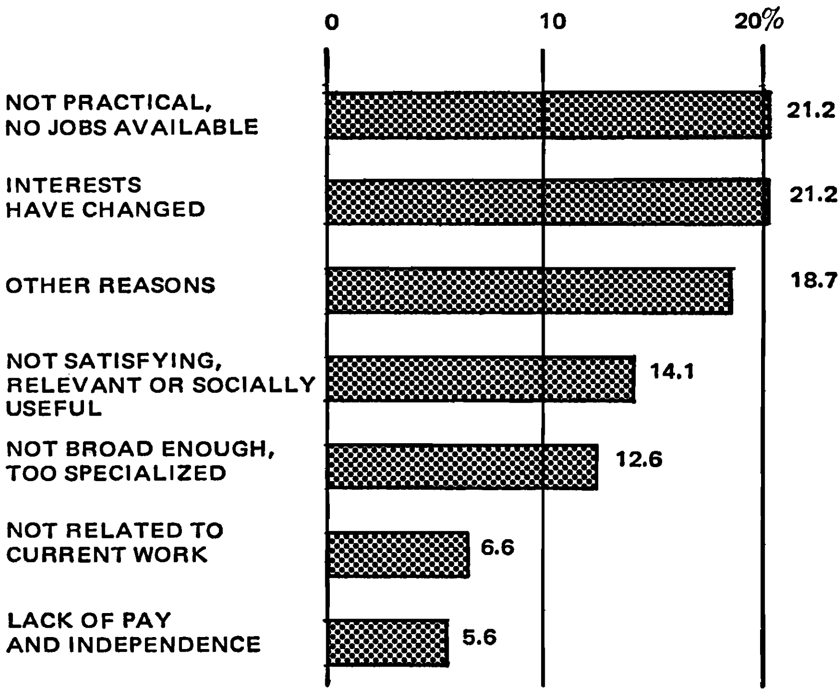
In eight of the ten "satisfaction questions" there is a definite clustering toward the upper end of the rating scale and from one-fourth to one-half of the respondents register an answer in the 90-plus category. For the three graduating classes surveyed, we conclude that the majority are generally pleased with their working conditions (Table A.21). Despite this high level of satisfaction we found frequent dissatisfaction among the more recent graduates regarding the relation of their education and employment. There are also expressions of "second thoughts" about their occupational choice, comments on recommending a scientific career to others, and concern about the labour market for young science graduates.

"Second Thoughts" and Comments by Respondents

Would chemistry and physics honours graduates select the same major again, if given another chance? Would they recommend the physical sciences, in general, as a field of study to a high school graduate? In general, from 60 to 70 per cent of each class would choose the same major again; a substantial proportion thus feel that for them a chemistry or physics honours program was the right decision. About two-thirds of the respondents also would advise a high school student to select a science major, but half of this number put major qualifications on their recommendation, ranging from having a certain aptitude to being fully aware of the current job situation. The details are shown in Table A.7.

The endorsements of physical sciences by those in different occupations show a clear pattern and contain no real surprises (Table A.8). Those who are now professors and high school teachers generally give warmer recommendations than those working as industrial scientists, managers or in other occupations. This is especially so for the 1954 and 1959 classes. Those in the 1964 class who entered industry seem to be at least as pleased as their academic counterparts, which is an encouraging sign for the attitude of scientists in industry. The relatively high percentage of those in management positions who would choose the same major again may indicate that a high quality undergraduate education is considered valuable even by those whose vocational concerns have changed. But cutting across occupational lines, a third of our respondents marshall a variety of reasons why they would not elect to study science, if they could start over again (Figure III.18).

Figure III.18–Reasons Given by Those Who Would Not Choose Physical Sciences if Studies Were Done Again: Selected Members, Classes of 1954, 1959 and 1964, BSc (Hon)–Chemistry or Physics–Canadian Universities



Source: Primary Survey.

The major theme of the comments is the need for broader undergraduate education, a reflection of changed interests, some dissatisfaction with the nature of the work, and worry about the labour market. In looking back, many see their course of study as too rigid or at least not allowing for pursuit of new interests or for changing fields. They see the present system of physical science education designed for those who have made an irrevocable decision to become scientists. A man who is now head of a high school science department would have liked more physics and biology because he is expected to administer them as well as chemistry; a physics graduate, working as an operations analyst wishes he had taken more mathematics and computer science. The lack of applied courses is viewed by many as limiting employment opportunities; entering industry they found themselves far too academically oriented. Those who did not enter graduate school or follow an "honours program – graduate school – professional scientist or university teacher" career pattern are most vocal in this regard (See Apprendix B).

One gathers from the above and previous evidence that it would be wise to encourage students entering physical science to combine specializations. This would permit the flexibility necessary to obtain various types of employment and to pursue new interests. Those who decide that they want to work in physical science can increase their specialization in graduate school. The current squeeze on job opportunities for physical scientists makes this a practical solution; many graduates find themselves forced to seek positions in an ever-widening circle. Even if an abundance of science jobs existed, many undergraduates would (voluntarily or otherwise) change their interests over time and a limited undergraduate education restricts their mobility into what they later may consider more fulfilling fields.

Those who felt that an undergraduate degree in physical science was inadequate preparation for a fulfilling career cited the lack of jobs for those at the bachelor's level and said a graduate degree was only useful for those interested in research. They generally felt that an engineering or technical education would have been more appropriate for them. But the desire for more courses in the humanities, the social sciences, and the history and impact of science, also came through clearly in the remark of these respondents. This is especially interesting since some university chairmen have suggested that science students in the past have avoided social sciences and humanities "like the plague". Graduate school was generally seen as the appropriate place for specialization. But even here, the graduates would like to see some reforms introduced. They object to professors who view their doctoral students as a way of re-creating themselves and of assuring a continued flow of men into the teaching of sciences at the university level. In a certain sense, academia, industry and themselves are all taken to task by the respondents.

IV. Comparisons with Related Studies

Are Canadian scientists unique? How do they compare with those in other countries? What do the differences or similarities imply? To answer such questions and to place the findings of the study in a broader framework, we studied data available from other countries. Several questions in our survey were adopted from other studies, this makes possible direct comparisons with physical scientists in Canada, the U.S. and the U.K. The latter countries, like Canada, are developed economies, have an extensive system of higher education, and exhibit concern with the utilization of their highly qualified manpower.[1]

This chapter presents findings from other studies on selected characteristics of physical scientists, including their background, education, productivity, employment, and utilization. Such presentation allows for interesting comparisons and throws the nature of the scientific career into sharp relief. It also enables us to draw conclusions about Canadian scientists in a comparative framework rather than in isolation.

Background, Education, and Personality Traits

The stereotype of scientists' backgrounds is being eroded, but there is still truth to the statement that they have a relatively high social origin and that in Canada especially they are professionally rather than career oriented. As already noted, Canadian arts and science undergraduates rank considerably higher on practically all socio-economic scales than their education and engineering colleagues.[2] Additional evidence from numerous U.S. and Canadian studies indicates that physical scientists in both countries can be described as highly intelligent, concerned with their work, independent, self-confident, and more introverted than college graduates in general.[3]

On the matter of occupational choice, the reasons for selecting a (physical) science career are undoubtedly complex. Nevertheless, we asked our sample of Canadian honours graduates in science to state the key factor in their choice of a university major. The results for physics honours undergraduates in Canada and their counterparts in the U.S. can be found in Table A.23 in Appendix A (we have no comparable data for chemists). The findings are interesting and the differences are significant, reflecting as they do underlying industrial and utilization patterns. Canadian physics majors mention inspiration at the high school level and the challenge of the subject most frequently as their reasons for their choice; in contrast, the U.S. graduates give inspiration at the college level and career considerations as key influencing factors. The results show a much stronger science-for-science's sake orientation and a much weaker consideration of career aspects among Canadian than U.S. physics graduates. They mirror and reinforce the industrial distribution of the two groups: a much smaller share of Canadian than American physicists work in profit-making enterprises.

In previous chapters, we commented on the nature of Canadian science education and especially the structure of chemistry and physics curricula.[4] Comparisons were drawn with other programs, especially those in the U.S. In the U.S. generalists are produced at the undergraduate level: specialization occurs during postgraduate work. British scientists and engineers, on the other hand, have a more specialized first degree course and the proportion of generalists is about 15 per cent or less compared with 65 per cent in the U.S. In our view, the training of Canadian honours graduates is more like that of their British than their American counterparts. In other words, educational patterns tend to reinforce the existing industrial situation in each of the three countries. The remoteness of science education and scientific research from applied considerations has been the topic of many reports in recent years, especially in Canada and the U.K. (One by Lord Rothschild recommends the integration of science with other pursuits and suggests that scientists get administrative experience early in their careers.[5])

Motivation and Productivity

Managers of research, whether in government or industrial laboratories, are interested in the payoff from such activity; university administrators are also keenly concerned with what the faculty does and produces in conducting basic research. We have not probed the topic of research management or the question of motivation, but some comparative statistics on the productivity of scientists are available from our and other studies.

If we accept hours worked as a crude indicator of input, we find that our sample of Canadian science graduates is a hardworking group indeed: members of each class, on the average, work slightly over 50 hours per week. A corresponding figure for science PhDs in the U.S. is 44 hours for those in industry and government and 50 hours for those in academic employment.[6] On the output side, we must again resort to a crude measure, namely the number of publications. Here again Canadian and U.S. scientists are comparable. In our sample the average number of journal publications for those having a PhD ranged from 5 to 7 depending on class, while for a slightly older group of PhDs in U.S. industrial laboratories the range was 6 to 8 publications.[7] Apparently, while the majority of U.S. scientists are in industry and the majority of Canadians are in academia, the pressure to publish is strong in both places.

There is disagreement on what constitutes the ideal environment for scientific pursuits, but it seems that a hierarchical, highly structured workplace will not suit scientists. Scientists, like other professionals, are motivated chiefly by intrinsic factors rather than by so-called "job hygiene" aspects. However, there is evidence that in times of economic uncertainty, such as now, scientists are increasingly influenced by job security considerations. A recent study of U.S. scientists and engineers indicated that, as of late 1970, although interesting and challenging work was still the prime motivator, as it was in the 1950s and 1960s, job security has become an important consideration. It also found that off-the-job education and training sponsored and encouraged by the employer, could strengthen the individual scientist's feeling of security.[8]

Employment

We are now ready to show specific comparisons on employment and utilization of scientists in Canada, the United Kingdom, and the United States.

All three countries have highly developed economies, though their industrial structures and performances differ.[9] Table IV.1 shows that all three developed their resources of highly qualified manpower to a high degree. Differing education systems and socio-economic conditions undoubtedly have an impact on the proportion who go to university and on their distribution by industry; nevertheless, we contend that meaningful comparisons can be drawn.

Table IV.1–Population, Professionals, and Research and Development Expenditures, Selected Countries, Late 1960s

Country	Highly qualified personnel as % of active population	Scientific and technical personnel as % of active population	University Graduates as % of total population	Gross domestic R & D expenditure per capita (dollars)
Canada	15.0	2.0	4.3	32.0
U.S.	16.7	2.4	7.6	110.5
U.K.	11.1	2.8	2.8	39.8
European Economic Community	10.0	2.7	2.8–3.1	n.a.

Source: Reviews of National Science Policy: Canada, Organisation for Economic Cooperation and Development, Paris, 1969. Pages 24 and 28.

The information on industrial and functional distribution of science graduates and scientists in Canada, the United Kingdom, and the United States is presented in Tables A.24 to A.28 in Appendix A. The most striking finding, already alluded to, is the relatively high proportion of the Canadian science graduates in educational institutions and the relatively low share in industry when compared with their counterparts in the U.K. and U.S. This phenomenon is especially pronounced at the PhD level (Table A.26). The industrial deployment patterns affect the functional distribution, with a relatively high share of Canadians listing teaching or research as their key activity. Due allowance must be made for societal differences in the attitudes of scientists toward careers in industry and of employers toward science graduates; and in what is deemed to be the "proper" type of education for a senior administrative career.[10] But given the nature of the three economies, the educational as well as research and development expenditures per capita, we can explain this situation only in terms of career choice and employment opportunities.

Another reason why Canadian science graduates from honours chemistry and physics programs see themselves, and are seen by their professors, as future educators at the university level, is the lack of interest on the part of Canadian industry in honours graduates, especially those possessing the doctorate.[11] Although we cannot prove it, the two aspects seem to reinforce each other; science honours graduates and industrial employers in Canada do not see themselves generally as suitable partners.

In two recent reports, one on basic biology and the other on basic research, the Science Council has recommended that universities, in consultation with outside experts from government and industry, develop broader programs (even at the graduate level), to increase the flexibility and cross-discipline expertise of graduates. Students, especially those with advanced degrees, are told that in the future applied research will likely grow faster than basic research and that job openings will be more numerous outside than inside academia. More mechanisms, such as NRC-deferred fellowships, industrial fellowships, part-time appointment of scientists to academic and industrial positions, may be needed to close the gap between the university and industry.[12]

The Science Council affirmed that the current lack of jobs for university graduates in science-based industry in Canada is caused by a number of impediments to innovation in general, not just by problems in research and development. One facet of this is that, compared with other countries, Canadian industry is a "low-performer" in research and development and consequently relatively weaker in its demand for R & D manpower. (In 1967, Canadian industry did 37.7 per cent of all R & D compared with 69.8 and 64.9 per cent respectively in the case of U.S. and U.K. industry.[13]) The Council dwelt at length on the rôle of innovation in Canada; it recommended that more emphasis be placed on preparing broadly-trained graduates who have an appreciation of management skills and an ability to put existing information to work.[14] In addition, although it has been shown that U.S. subsidiaries spend relatively more on R & D than comparable Canadian-controlled firms[15], it is probable that a typical subsidiary spends relatively less on R & D than does its parent operation in the U.S. In fact, the relatively better performance of U.S. subsidiaries simply reflects a generally low level of R & D by indigenous Canadian firms.[16] Certainly the "cream" of Canadian chemistry and physics graduates have not chosen and/or have not been accommodated in great numbers by Canadian industry.

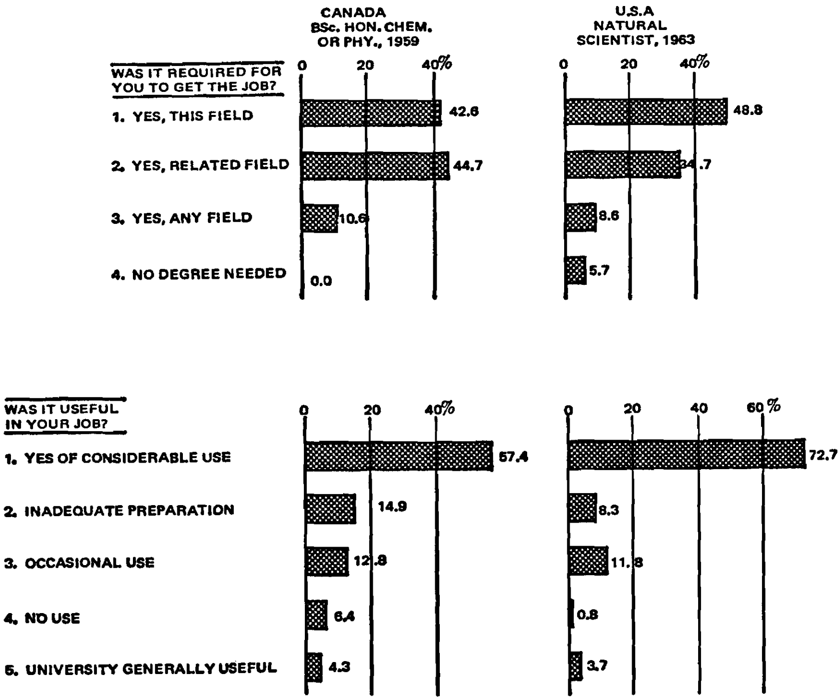
The importance of "rôle-models" for the career orientation of individuals should not be underestimated. The high proportion in executive posts in the U.S. even at a comparatively early age (one in eight of the 1960 cohort, shown in Table A.28) must act as an incentive for future aspirants.

As a final comment on the deployment of scientists we call attention to their distribution within the educational sector. Whereas in Canada and the U.S., the proportion of PhDs in science who work in secondary or primary schools is in the range of only 3 per cent, the corresponding figure for British science PhDs is close to 12 per cent. PhDs often "look down" on employment opportunities in educational institutions below the university level, but the example of the British groups indicates that secondary school teaching is an alternative, especially when openings in higher education become scarce. Concerning the matter of utilization, the next section illustrates that jobs in high schools offer definite rewards and benefits. (Possible impediments to the employment of PhDs as school teachers include required pedagogical qualifications and the reluctance of school boards to hire people with "too high" qualifications: but these barriers are not insurmountable.) However, more prestige is accorded a sixth form teacher in Britain, who teaches at a level similar to our first-and second-year university.[17]

Utilization

Our assessment of utilization in the case of the Canadian graduates proceeded on two fronts: use of education on the job and relative satisfaction with the work as shown by certain job characteristics. For the former aspect of utilization, we have comparative statistics for Canada and the U.S., for the latter for Canada and the U.K. (Figures IV.1 and IV.2 and Tables A.29 and A.30 in Appendix A).

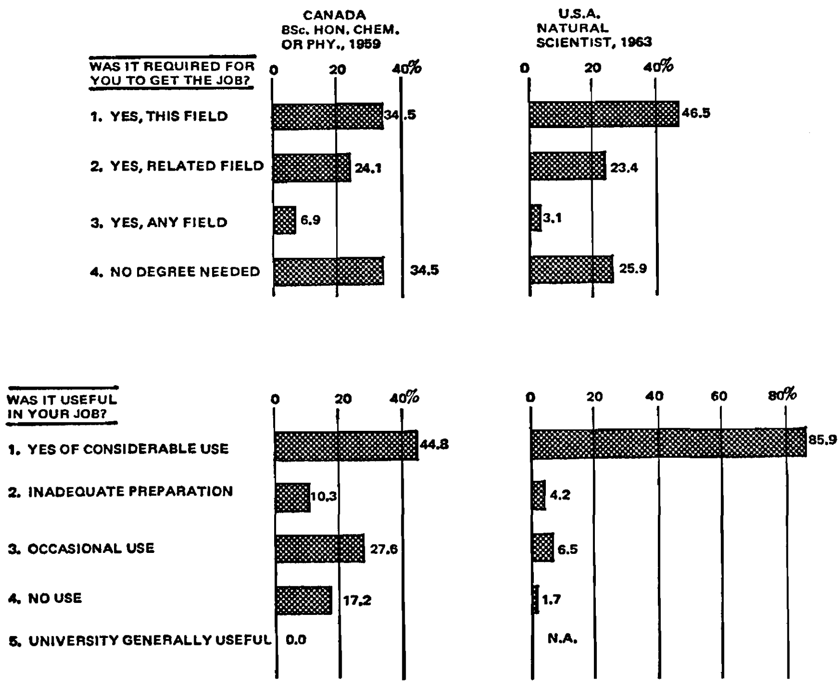
Figure IV.1–Utilization of Undergraduate Education on the Job: Selected Canadian and U.S. Science Graduates Working as Scientists



Source: Canada–Primary Survey.
U.S.A.–L.M. Sharp, *Two Years After the College Degree*, Bureau of Social Sciences Research Inc. for the National Science Foundation, Washington, 1970. Pages 230-238.
L.M. Sharp, *Five Years After the College Degree, Part II, Employment*, Bureau of Social Sciences Research Inc. for the National Science Foundation, Washington, 1966. Pages A-14 to A-16.

In regard to the utilization of undergraduate and graduate education at work, the U.S. graduates show higher scores than the Canadians on just about all aspects. In other words, a larger proportion of the former claim that the field they majored in is a prerequisite, the undergraduate/graduate education they had is of considerable use, and someone with different qualifications could not perform their work. The figures generally are 80 per cent for the U.S. compared with 55 to 60 per cent for the Canadians. This is true for science graduates in general, i.e., in a variety of occupations and industrial settings, including graduates working as scientists and as teachers. An explanation of this phenomenon can be sought in a variety of factors, chief among which is the better match between the type of work sought and the actual job situation, which is more easily provided in a vast economy which allows more specialities.

Figure IV.2–Utilization of Graduate Education on the Job: Selected Canadian and U.S. Science Graduates



Source: Canada–Primary Survey.
U.S.A.–L.M. Sharp, *Two Years After the College Degree*, Bureau of Social Sciences Research Inc. for the National Science Foundation, Washington, 1970. Pages 291-294.
L.M. Sharp, *Five Years After the College Degree, Part II, Employment*, Bureau of Social Sciences Research Inc. for the National Science Foundation, Washington, 1966. Pages A-40 to A-41.

We have one set of comparable British statistics, based on information from the 1961 Census: about 16 per cent of British scientists were in occupations where it was unlikely that they were making direct use of their qualifications.[18]

Quantitative measures of job characteristics and satisfaction are available from our survey and from a similar report by Kelsall in Britain. We have converted the raw scores from both studies into a rank order; the results are shown in Table A.30. There are numerous similarities on a relative basis, among the different sectors and, in fact, the results for Canada and the U.K. are practically identical. The following characteristics are said to be present to a relatively high degree for science graduates in university, high school, industry, and government settings in both countries: scope for initiative and freedom to develop one's ideas; opportunities for intellectual development, congenial colleagues and good working conditions; and good salary, security and prestige. The following characteristics are present to a much lesser extent: novelty and variety in employment; opportunities to advance through one's own efforts; and high level administrative or planning tasks.

Separating the characteristics into two groups, those which are present to a high and those which are present to a low degree, there are great similarities among various industrial settings. Looking at just the high ones, we perceive some differences, of an expected nature, by type of industry or occupation. For example, university professors rank scope for initiative and opportunities for intellectual development at the top, while scientists in industry and government give the highest marks to a congenial atmosphere and a good financial situation. But a very significant finding is that those working in high schools see their work as socially useful; in fact, this aspect is rated at the very top of their list, while it receives a low score by those in other sectors of the economy. These results imply that different work settings offer different job characteristics and sources of satisfaction. In advising science graduates about job opportunities, it is important to stress this point, namely, that rewards can be had in a variety of settings, although the types or sources of such satisfaction will differ from sector to sector.

V. Conclusions and Implications

There is much concern in Canada with national science policies, the process of education, and the labour market for professionals.[1] It is in this atmosphere of concern, reassessment, and ambivalence that the findings and recommendations of this study are offered. The study examined only selected aspects of the utilization of Canada's human resources, dealing specifically with a group of physical scientists and their career patterns. But we strove for a broad perspective, considered published information, and undertook a primary survey to complement available statistics. In examining long-run trends and the present situation we were aware that the future environment may well be different; but the rationale for the study was the idea that the past and present could offer clues to the future. In this sense, the study is, hopefully, both retrospective and forward looking.

The conclusions focus on general trends, on highlights from the study itself and also on findings from similar studies. The results and their implications are addressed to four distinct audiences: individual scientists; educators, specifically those in universities; industrial management; and government officials concerned with science policy issues.

Conclusions

General Trends

The past two decades have seen a rapid increase in the demand for higher education. This has meant major challenges to individuals and existing institutions to which, as a general rule, they have responded flexibly and well. In Canada, at the undergraduate level, there was a definite swing towards the pure fields of arts and science and away from the applied subject areas. At the graduate school level, where enrolment also rose sharply, there was an opposite trend, that is toward applied fields. This tendency to specialize at the graduate level is laudable, for a broad foundation implies flexibility in a changing world. The demand for university education will continue to be strong in Canada in the 1970s, but we can expect a slackening in the rates of growth and further changes in enrolment by field. A concensus appears to be emerging about creating further flexible arrangements which would facilitate transfers among courses, majors, institutions, and later on, among occupations.[2]

In labour markets new forces are also operating. Though continued growth in employment is expected in most areas, total demand for and supply of science manpower in the 1970s will be more in balance than in the 1960s. There will probably be a shortage of the kinds of jobs that scientists traditionally have held. And there will no longer be a labour market clearly favouring employees and new entrants. The structure of demand is likely to evolve rapidly, calling for flexibility on the part of the labour force. A vital rôle in this situation can be played by continuing education on the one hand and labour mobility on the other. To mention just one key change, a high proportion of science graduates will have to reorient themselves, away from teaching at the university level and basic research in government laboratories and toward positions in industry, high schools, international organizations, and ad hoc, mission-oriented teams.

A third area of prime interest, besides those of education and employment, is utilization, While there have been many publications between 1950 and 1970 on this topic, much of the available information proved to be either very narrow or very vague. While it has been shown that science graduates are seldom unemployed, that many pursue scientific activities and that their absolute and relative earnings have been rising, we knew little about how well scientists were utilized in various sectors and functions. We proposed to learn more about this, i.e., about how useful and necessary their education is in the performance of their work and how much they are satisfied in their jobs. Thus, we chose to emphasize this aspect in the primary survey and to make international comparisons wherever possible.

Selected Highlights of the Primary Survey

At the heart of our study was a mail survey of selected Canadian science graduates – those who received a BSc (Hon.) degree in chemistry or physics in 1954, 1959 and 1964. The findings shed light on hitherto untouched areas, in some cases confirming and in others contradicting popular conceptions. But hopefully, the results give additional insights to complement the general trends just sketched.

Before analysing the views and circumstances of Canadian science graduates, their academic training was examined; specifically, we looked at the structure of physics and chemistry undergraduate honours programs at Canadian universities in 1950 and 1970. In contrast to changes in content (mostly the presentation of advanced topics in the earlier years), the structure of programs remained unchanged and rigid. This meant that the emphasis was placed on the major and there was little allowance for so-called elective courses. By its very nature, the honours program also stressed physical sciences, with practically no attention being paid to broader implications and applied aspects. In this, the Canadian honours curriculum was about half-way between the highly specialist nature of higher education in the U.K., and the generalist tone of U.S. academia.

The evaluation of their education by our sample of graduates was along expected lines. They praised the rigour of their training and also the depth given to the major field; but they would have liked more flexibility and more freedom in their undergraduate programs. Graduate school was seen by them (and enrolment trends further support this, as we saw) as the appropriate place for specialization. The views just expressed are shared also by many industrial managers and observers of world-wide trends in education.

Challenge and interest in the field of science and inspiration by high school teachers were key influences in the choice of major by the 600-plus respondents. However, for French-Canadians, career considerations still loomed important. Academic performance, which, incidentally, did decline from the 1954 to the 1964 class, influenced graduate schooling and occupational choice; those with high marks sought and were being sought primarily for university positions. A large proportion of our sample received advanced training; over 80 per cent of the group enrolled in graduate school at some time, and about 70 per cent hold an advanced degree, many of them from U.S. universities. A surprisingly large proportion of graduates also participated in non-degree, non-credit courses as a means of continuing education, although they preferred if credit could be obtained for academic pursuits.

At first sight, the employment patterns – like those of graduate schooling – confirm the traditional view of honours graduates as future academicians: almost one-third of the respondents belong to the professorial ranks. But an equally large proportion function as physical scientists, with the remainder in high school teaching, managerial or other civilian occupations. While the majority pursue scientific activities, there is a tendency to undertake administrative tasks as promotions occur. Thus, honours graduates in science *do* fill a variety of positions and perform a wide range of functions. Information on job offers and job changes indicate the existence of a strong labour market in the 1955–1970 period, favourable to science graduates. Starting salaries, current earnings, and annual increases all show a generally positive situation. Although generally unaffected by the problems of more recent graduates with regard to job opportunities, concern with this situation is quite evident in our sample.

The subject of utilization was probed in several ways and the evidence is as follows. Almost three-fifths of the graduates make considerable use of their undergraduate major in their current work, while one-fourth make little or no use of it. But only one-third see the specific field of their academic studies as a prerequisite for their jobs and a similar proportion say that a related field would do just as well. The majority of the sample consider their education and jobs well matched, but a substantial minority state that less formal academic training would suffice for performing their present tasks. Those working in administrative positions comment on their lack of education in the social sciences or in business subjects, while others would have liked more courses in the humanities.

The work environment and specific circumstances at work are generally rated satisfactory or "slightly above average". Intrinsic factors such as recognition and achievement are the key motivators and satisfiers; fortunately, different ones appear in different settings. For example, those in high school teaching see their work as having much social usefulness, a characteristic seldom mentioned by college professors. But the reactions of the more recent graduates suggest that job availability and job security are growing in importance as an important point of consideration. About two-thirds of the respondents would elect the same major again. About the same proportion would recommend a science major to a young high school graduate today; many would do so, however, with substantial qualifications, especially in the light of a much tighter labour market.

Relevant Findings from Other Studies

Canadian science graduates differ little from their American or British colleagues in terms of socio-economic background, personality traits, motivation, or productivity. There are some differences in their educational and employment patterns, reflecting the underlying nature of the respective institutions, economic settings, and policies. Because of this, we found Canadian (honours) science graduates more academically and less industrially oriented than their U.S. colleagues.

The most interesting comparison we could make was in the area of utilization. Science graduates in the U.S., and to some extent in the U.K., showed a closer match between undergraduate education and their current work than was the case for their Canadian colleagues. Approximately 80 per cent of the U.S. and the U.K. science graduates made considerable use of their undergraduate education against 55 to 60 per cent for the Canadians. A similar percentage from each country claimed that a specific undergraduate program was necessary for the current work assignment. The reasons for these phenomena may be complex, but the findings argue in one of two – or perhaps both – directions. A better "match" may be achieved by altering activities at the work place and/or by making the Canadian science honours program more general, leaving specialization for graduate school.

In terms of satisfaction and work environment characteristics, we found great similarities between Canadian and British graduates. In both cases, graduates can function and attain rewards in a variety of settings (with the nature of satisfaction partly dependent on the specific circumstances).

The Implications of the Findings

In exploring the implications of our findings, we shall make only brief references to the results, since they have already been stated at length in this and the two previous chapters. Furthermore, we shall not identify whether the relevant findings comes from our primary survey, general trends in Canada, or the comparative international analysis, since, in many cases, a combination of findings leads to our suggestions. Finally, in choosing between "going out on the limb" or being too timid, we would plead guilty rather of the former than the latter.

For Individuals

A narrow undergraduate education restricts mobility into and among a variety of occupations and functions. The trend, in spite of obstacles, is toward a broad foundation at the bachelor's level, with specialization coming later. But this will place a greater burden of choice upon students, who will be more involved in planning their own career sequences. The need of students for more and better career information will correspondingly increase.

Students should seek counselling and information from a wide variety of sources including government and industry officials, professional associations, and practising scientists. One effective way of accomplishing this would be through the cooperation of alumni associations and associate/assistant deans who would schedule lectures by alumni and other speakers. Practising scientists and other professionals could thus offer information and feedback to college students, counsellors and policy-makers in a variety of ways (from informal lectures to conferences).

Even the most effective counselling system should not be expected to enable a student to make educational or career choices irrevocably at a particular time in his life. Not all students who major in physical science will want to work in the field. Changes in outlook, preferences, and sources of satisfaction will occur; the labour market will be in a continuous state of flux as old opportunities wither while some new ones open up. Some jobs will come to require less education, others more; some will still focus on scientific work, while others will demand new skills, The close matching of one's education with job requirements, not always feasible even in the high demand decades just gone by, may become more difficult.

Potential science (and other college) graduates should be encouraged to combine a number of specialties rather than concentrating on one narrow field. They should not "dabble" in numerous areas, thereby scattering their efforts, but intense pursuit of, say, two to three areas should equip them for various types of employment and also allow greater latitude in fulfilling new interests which may develop later on. At the undergraduate level, the ability to learn and a broad foundation should be the two key acquisitions.

University students, until now, were subjected to a lock-step type, continuous education of 16 or more years. They knew little about the post-school world and received little or no feedback from on-the-job experience (with the exception of summer jobs, which, however, were often not of great relevance). On the other hand, once on the job, education may still be pursued in an intense way.

Many university educators are sympathetic to the idea of a break in the educational process. A majority of deans and professors indicated in a recent study for the Science Council that they favour students obtaining experience outside the university before they begin graduate studies.[3]

Students should consider the advantages of a break in their science education during or following completion of the first degree. This would provide them with an opportunity for work experience, facilitate their choice of a career, and possibly encourage future scientists to work in areas now deprived of their expertise, including industry and government in general, as well as socially oriented programs such as Opportunities for Youth, Company of Young Canadians, Canadian University Service Overseas. They should explore and relate science education to employment and to the broader problems of society. They should continue their education beyond formal degree work in a variety of ways, ranging from in-house to extension courses; professional development is a lifelong process.

The occupational pursuits of science graduates so far have fallen into traditional and stable patterns. About three-quarters of them belonged to one of three categories: professor at a university or at a junior college; teacher at the high school level; or physical scientist working in the undergraduate field of specialization in industry, government, university, or independent institute. The remaining fourth was distributed among a wide variety of occupations. The majority are not the future generation of university professors and the labour market is not likely to provide many such openings.

Similarly, opportunities for advancement in research areas in industry or government may be limited. But other opportunities will continue to exist. The continuous flux in the labour market as well as in manpower poses extra challenges and pressures for potential entrants into the labour force.

In view of the changing market for highly qualified manpower and the

track record of manpower forecasts so far, individuals should be encouraged to prepare for uncertainty by obtaining the kind of education which will make them adaptable to changing circumstances in the future. They should consider the idea of entering non-traditional fields or creating, in an innovative sense, their own job opportunities. They should realize the rewards (financial and non-monetary) which various settings offer. The final degree should not be viewed as the end of education, and curiosity coupled with a flexible attitude should guide graduates in their job search and job performance.

Utilization is a complex phenomenon, involving as it does the matter of employment, using one's education at the work place, job satisfaction, and a host of related factors. A relatively small-sized economy over a wide territory, the nature of modern technology and industrial requirements do not always permit the degree of specialization or "matching" possible in a larger setting.

Science graduates may wish to consider the matter of utilization in a variety of ways. They should realize that one can prevent disappointment in the world of work in a number of ways: 1) a broad education, followed by concentration in two or three areas, 2) maintaining a flexible attitude on the job, 3) job mobility – both within a given organization or among employers, 4) accepting the different rewards which different settings may offer, 5) creating one's own job openings or promotion opportunities, 6) retraining oneself in a new field, and 7) being aware of current and future trends in education and employment.

For Educational Institutions

We found a major evolution in the course content of undergraduate science programs at Canadian universities. This was not matched, however, by progress in the structure of programs, especially the honours curriculum, yet the arguments are strong for stressing the unity of science and avoiding the threat of obsolescence to the young scientist. In addition, it is important that graduates perceive the broader implications of their studies to environmental and other considerations. The findings also demonstrate a positive correlation among flexibility of education, employment opportunities, and subsequent job satisfaction. It is recognized that prerequisite rules are necessary and that a structured sequence may serve as a preparation for advanced or graduate studies. But the results argue for a broad undergraduate foundation in the sciences (and, indeed, other fields).

Without diluting the intellectual demands on the student, less rigidity in science studies can and should be achieved in a number of ways including combined majors, increased amount of applied work, more elective courses and transferability between the honours and the majors program (even to the possibility of abolishing the distinction between honours and majors). Specifically, the undergraduate honours science programs at Canadian universities should be re-evaluated and probably restructured. Despite the existence of major and general streams, more flexibility in the honours programs themselves is warranted. Students in the honours curriculum should be encouraged to have a greater voice in developing their own course sequence; in any case, more electives and fewer required courses should be the rule. The precise combination of means to attain flexibility can be developed in the light of circum-

stances at each university. We applaud the trend of department chairmen across Canada getting together, both provincially and nationally, to discuss curriculum reform and related matters. We would deplore attempts to insist on more required courses, but endorse the idea of maintaining high standards in all courses.

Worldwide trends in education and specifically undergraduate science education yield unmistakable evidence that the programs offered need critical scrutiny. The degree of specialization and the whole syllabus are coming under probing eyes. Trends are discernible pointing the way toward the "non-specialist chemist or physicist", but even the specialists are told to explore their fields for relevance, to bring it into closer contact with society and its problems (see the IUPAC survey, Chapter III, footnote 14).

There should be breadth (as well as depth) to science and humanity offerings at universities. More emphasis on the social sciences (including business and management), the humanities and on the relationship of science and society in the undergraduate science curriculum seems strongly warranted. This should make for more enlightened, socially oriented students, widen student choice of academic courses, and promote subsequent flexibility in all aspects of employment and leisure-time activities.

Occupations such as high school teaching, industrial management, and positions in government departments, as well as in other categories – ranging from actuary to pollution control administrator – may be sought in future by an increasing share of science graduates, including those from honours programs and those with advanced degrees. While much of the adjustment may come at university entry levels, we must face the situation of physical scientists retraining themselves in mid-career. This may be necessitated by shifts in job openings as well as in career interests. In either case, the possibility of returning to academia (part or full-time) cannot and should not be ruled out.

There appears to be a considerable potential for the expansion of continuing education. The study by J.C. Richer for the Science Council indicated that less than one-third of Canadian university departments offer refresher courses. Less than one-half of Canadian universities offer extramural postgraduate degrees to people employed in industry or government for work done on the job, and less than one-third encourage it.[4]

The findings of the study support the desirability of moving away from the traditional patterns of education followed by occupation toward one where education and work are interspersed throughout a lifetime, and where the emphasis is on career as well as on personal development. Experimentation and wide participation in continuing education programs should be encouraged. Special attention should be paid to retraining and to facilitating transfers among programs. The nature of the MSc and PhD degrees and possible alternatives need to be examined.

Science students who received high grades as undergraduates were encouraged to enter graduate studies and ultimately to return to teach in universities. Yet there was objection to professors who view their (graduate) students as a way of re-creating themselves and of assuring a continuing flow of men into the teaching of sciences at the university level. There was a higher proportion of the Canadian science graduates in educational institutions and a lower share in industry compared with their counterparts in the U.K. and the U.S. But the research also showed both ample opportunities and attractive benefits outside the halls of ivy.

Educational institutions should increase efforts to provide objective career advice and vocational guidance. Professors should refrain from trying to "re-create themselves" and from influencing honours students only in the direction of university careers. Indeed, they should point out the opportunities and sources of satisfaction in other fields – industry, government, and high school teaching. Professors who consult for or visit non-academic institutions can be in the vanguard of such a movement.

For Industry

For our graduates, challenge and interest, rather than job-orientation, was the prime consideration in their occupational choice. The physical science curriculum in general was seen as useful in subsequent work assignments, although many who entered industry found themselves too academically oriented and lacking applied courses. The specific major and honours nature of the program was rated of secondary importance for present tasks. Has the training of the highly educated been "ineffective" or have employers had too rigid a definition of the "proper" education? Science honours graduates (especially those with advanced degrees) and industrial employers in Canada often do not see themselves as suitable partners, and as a result the most able of Canadian chemistry and physics graduates have not chosen (or have not been accommodated by) Canadian industry. Yet many able U.S. graduates in industry (with or without graduate schooling) feel that the education they took is useful in their present jobs.

An interesting example of what can be done to improve university-industry communications is provided by the University of Toronto Institute of Aerospace Studies. Four years ago, a committee of industry representatives was formed to help advise the university on curricula. Regular seminars and plant tours by undergraduates and postgraduate students were undertaken to exchange information about curricula, job opportunities and student aspirations.

The scope for increasing this kind of interaction is considerable. A recent study by the Science Council indicates that slightly less than one-third of Canadian university departments receive advice from industry or government agencies in discussions of curricula. In most cases, the reason is that this cooperation has never been sought. On the industry and government side, two-thirds indicated that they would be willing to help develop university curricula.[5]

This is not meant to suggest that employers should no longer be responsible for any training and education. There will always be a need for the training by employers to adapt university graduates to the job.

Canadian industrial employers should be encouraged to recruit science graduates and to offer challenging positions to them, trying to match interests and job activities. Industrial leaders should provide feedback to educational institutions and university students, and should be involved at least in an advisory capacity in the planning of programs. The nature of assignments, the potential benefits as well as the problems which may face those entering

industrial positions should be exposed. There is an opportunity here for industry, both in influencing academia and in recruiting able men from the academic pipeline.

The great majority (about four out of five in all three honours science graduating classes), viewed their honours program or education in a similar, related field as a prerequisite for their work, but almost as many mention a related field as the one they specialized in. Also, a significant minority made little use of their undergraduate major. It may be that the university degree in some cases is used to screen people for entry into jobs which do not really require a university degree (compare 97 per cent who thought that the undergraduate degree was a prerequisite to enter an occupation versus 80 per cent who found it useful on the job).

Industry should re-evaluate its jobs to see which do and which do not require university degrees (and advanced degrees). The nature of various assignments, tasks, and positions should be made clear to potential entrants. Employers should avoid assigning university graduates to low-level positions to avoid under-utilization, frustration, and high turnover.

One alternative to the pattern of possibly premature specialization is that those who decide that they want to work in physical science can specialize to a greater extent at the graduate level. Alternately, this could be an opportunity for broadening out into new areas which the graduates feel are in greater demand. Respondents who felt that an undergraduate degree in physical science was inadequate in leading to a fulfilling career cited the lack of jobs for those at the bachelor's level and said a graduate degree was only useful for those interested in research. They generally felt that an engineering or technical education would have been more appropriate for them.

Advice, assistance, and financial aid given by industry for undergraduate and graduate programs should be re-examined to determine if they tend unduly to favour one field or sector over another, e.g., pure science at the expense of applied fields or vice versa, or both at the expense of the social sciences. The possibility of extramural tenure of fellowships should be explored along with an expansion of cooperative programs.

The extent of actual movement and the potential for mobility is evidenced by the fact that job changes made by the respondents, involving a change in employer, industry, and occupation, have occurred more frequently than changes involving employer and industry or employer and occupation. The next most frequent job change was that involving employer only. Thus, the two typical patterns are a continuation in or a "clean break" from a career. Both are important and both types of opportunities need to be retained.

Scientists should be encouraged either to continue or to make changes in their careers as their abilities and opportunities dictate. Movement among the major sectors of the economy (academia, government, and industry) should not be discouraged. Barriers to temporary or permanent mobility, such as insistence on a rigid set of formal qualifications or the matter of pension transferability, should be examined and removed wherever possible. Both industry and government can play useful roles through granting official leaves of absence, transferring vested pension rights, publicizing specific openings,

and exchanging "talent data bank information". Risks to the individual and their organizations (admittedly real and substantial) should be carefully weighed against the potential benefits.

It would be naïve to expect that with the expansion of knowledge in the future, the knowledge-workers themselves can escape the problems of "future shock" and obsolescence of learning. Re-training is very costly. Since the greatest part of the cost consists of the foregone earnings of the trainees themselves, the appropriate division of costs among the trainees, their employers, and society is debatable and involves questions of both equity and economic efficiency.

The study by J.C. Richer indicates that more could de done to promote continuing education at the university level. Although almost two-thirds of industry and government employers offer their staff opportunities for updating and refresher courses, less than one-third of the university departments actually offer such courses.[6]

Industry should encourage and support continuing education and training on the part of science graduates. Opportunities for on-the-job upgrading should also be given to those without a formal undergraduate or graduate degree. The employer should be actively involved in planning and financing a variety of continuing education courses. Consideration might be given to arrangements similar to a recent French law, "loi du 16 juillet 1971" under which employers must set aside 0.8 per cent of total salaries (up to 2 per cent in 1976) for the re-education of their employees.

For Government

In general, all of the statements and suggestions made above for industry apply to the federal and provincial governments in their rôles as employers, as contributors (financial and otherwise) to the welfare of educational institutions and as sources of information for college students and graduates. But, in addition, governmental agencies, departments, and ministries have special duties vis-à-vis the education, employment, and utilization of scientists. These tasks are incumbent upon governments as repositories of information, key sources of financial support for higher education, and as guardians of full employment policies.

Projections of manpower demand and supply have not been remarkably accurate in the past. As one example, most official forecasts of future requirements for PhDs were highly optimistic, even in the mid or late 1960s.[7] Attempts to project future supply and demand have often foundered on the complexity of the system. Decisions about supply and demand of science manpower are made by different people and often for different reasons. Career decisions are made by individuals and their parents while decisions on educational investment and on investment in research and development programs are made by governments and by industrial firms. If all these decisions were completely co-ordinated, it would be the sheerest coincidence. Moreover, the mix of social goals and investment decisions can radically alter manpower requirements. The scientific manpower mix of a defence and space oriented economy, based on high-technology industry, will be quite different from one which leans more to lessening social disparities and to improving the quality of the physical environment.[8] Indeed, a "fine tuning" in the short run supply and requirements for science manpower is quite likely impractical if not impossible. Despite these difficulties, few concerned with education and manpower planning will concede that attempts should not be made to develop better projections in order to reduce the margin of uncertainty surrounding future plans by individuals and institutions. In fact, better information may be the most important single step towards improving the operation of the education/manpower system.

Some important steps are now being taken to fill the information gaps in manpower. The recently developed Economic Council of Canada econometric model, CANDIDE, is to be used as a framework by the Department of Manpower and Immigration to develop a sub-model of future occupational requirements.[9] Statistics Canada is planning to begin in 1973 a regular comprehensive survey of employers which will provide data on occupation by industry. This is the first time such comprehensive data will be obtained from Canadian employers. However, no information will be obtained on educational level by occupation.

Government agencies should continue to make manpower projections and to engage in manpower planning. To be fully effective, projections based on more comprehensive and current data should be made on a regular basis. The projections should be done by broad level of education and provide a range of possible future options. The results should be disseminated to counsellors, managers, and officials in industry and government and others concerned with career, educational, and manpower planning; feedback should be invited. In the generation and dissemination of manpower forecasts, we should consider alternatives and adjustments: fuller use of paraprofessionals; the fact that not all professional occupations will require a university degree; the relative ease with which labour markets for professionals adjust; and the fact that some sub-professional work will be present – and, in fact, seems desirable – in the work of professionals.[10]

The Canadian federal government, like those of other developed economies, has accepted partial responsibility for the promotion of full employment and for more effective utilization of human resources. It has also supported certain social experiments and instituted some innovative and imaginative practices.

Government agencies need to be innovative not only in regard to their own employment and the financing of higher education, but also vis-à-vis the general structure of Canadian society. Here is a partial list of desirable steps: further development and refinement of manpower information systems; continuous evaluation of worldwide trends in education; further studies of utilization patterns by occupations; facilitating adjustment of industrial and individual needs (including product and labour markets); streamlined administrative arrangements for exchanging scientists (and other professionals) among various sectors of the economy; creation of mission-oriented teams; refinement of simulation and forecasting models; cost-benefit studies (including consideration of social costs); re-evaluation of economic growth and technical progress; and the development of alternative scenarios for science in Canada and Canadian society.[11]

Epilogue

The state of science and the status of science graduates in the coming decades will be determined by a host of complex, interacting factors in and out of Canada. In dealing with the complex forces and "the speeding systems" impinging on us, we will need to look at society and its problems in a new way. Let us end our study by an attempt to do so.

Economic growth and modern technology have their ultimate *raison d'être* in offering us wider alternatives. They offer, hopefully, greater options in the use of resources. But all activities compete for limited time; even in Utopia, time will be a scarce resource. While we have not reached that day, we do have options now, and the production of goods will require even less time in the future.

Moreover, resources may be allocated either by the market or by the non-market system. Decisions may be made privately or collectively. Different combinations or scenarios can be envisioned. It seems clear, however, that the lines will become blurred. When is a professional really working and really resting? (And is continuing education work or leisure?) Is a corporation relying largely on government contracts really a private organization? If we choose to allocate resources to the production of goods will that make for scarcity of clean air and water? Will the establishment of new programs and social experiments lead to entrepreneurs moving to the public sector, and will this lead to centralization or decentralization?

For a developed economy, like Canada's, economic growth for its own sake is no longer warranted; the "quality of life" is a slogan heard increasingly. To move toward and achieve it, we shall have to do, individually and collectively, three things: make better use of our work *and* leisure time, humanize industry and everyday activities, and learn to live with, not rule over, our physical environment.

Scientists and engineers can point to many tangible achievements and results over the centuries. However, the important questions are being asked increasingly – but not always answered – by social scientists. And the answers – in part, in very vague form, and rather haltingly, to be sure – may be provided by the humanists. To the extent that scientists can aid in bridging the gap among the three solitudes, to that extent they will succeed. Disciplined training, continued education, research, the traditional scientific rôle of the pursuit of truth for the sake of truth are not questioned nor are they taken for granted. They will remain at the heart of each science graduate's professional development. But the extent to which those educated in science can assist us in solving the highly complex problems of a scientific-technological civilization – to that extent they will be accorded esteem by others and achieve self-esteem.

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Appendices

Appendix A – Supporting Tables A.1 to A.30

Appendix Table A.1–Enrolment in Canadian Educational Institutions–Elementary, Secondary, Post-Secondary, 1952 to 1970

Level	1 1951–1952 (thousands)	2 1959–1960	3 1969–1970	Average annual change 1952–1960	 1960–1970
Elementary	2 230	3 294	4 057	6.0	2.3
Secondary	394	715	1 640	10.2	12.9
Post-Secondary, Total	91	148	480	7.8	22.4
University	64	102	298	7.4	19.2
Non-University	27	46	182	8.8	29.6

Source: Columns 1 and 2: Z.E. Zsigmond and C.J. Wenaas, *Enrolment in Educational Institutions by Province, 1951-2 to 1980-1*, Economic Council of Canada Staff Study No. 25, Information Canada, Ottawa, 1970.
Column 3: Statistics Canada, *Advanced Statistics of Education, 1970-71*, Information Canada, August 1970.

Appendix Table A.2–Canada: Bachelor and First Professional Degrees, 1951, 1960, 1969

Field of Study	Number 1951	 1960	 1969	Per cent 1951	 1960	 1969
Total	**15 572**	**18 372**	**54 862**	**100 0**	**100.0**	**100.0**
Natural Sciences and Related Total	*6 109*	*5 550*	*13 039*	*39.2*	*30.2*	*23.8*
Agriculture	556	248	544	3.6	1.4	1.0
Engineering	2 425	2 171	2 961	15.6	11.8	5.4
Forestry	157	139	141	1.0	0.8	0.3
Health	1 906	1 681	3 004	12.2	9.2	5.5
Science*	1 069	1 311	6 389	6.9	7.1	11.7
Social Science Humanities and Related Total	*9 462*	*12 822*	*41 823*	*60.8*	*69.8*	*76.2*
Arts	6 094	7 206	25 404	38.8	39.2	46.3
Commerce and Business	708	1 059	2 263	4.6	5.8	4.1
Education	713	2 394	9 896	4.6	13.0	18.0
Other	1 998	2 163	4 260	12.8	11.8	7.8

*Data are not available by fields of study at the first degree level, except for honours science. Between 1960 and 1969, the proportion of all honours degrees represented by biological sciences increased from 5.8 to 10.7 per cent, while physical sciences declined from 29.1 to 19.8 per cent.
Source: N.M. Meltz, *Patterns of University Graduation by Field of Study in Ontario, Canada, and the United States, 1950-51 to 1968-69*, Institute for Policy Analysis, University of Toronto, July 1971.

Appendix Table A.3–Canada: Master's Degrees, 1961 and 1969

Field of Study	Number 1961	Number 1969	Per cent 1961	Per cent 1969
Total	**2 059**	**6 598**	**100.0**	**100.0**
Natural Sciences and Related, Total	*763*	*2 315*	*37.1*	*35.1*
Agriculture	37	102	1.8	1.6
Engineering	222	946	10.8	14.3
Forestry	30	37	1.5	0.6
Health	61	140	3.0	2.1
Science	413	1 090	20.1	16.5
Biological	138	385	6.7	5.8
Mathematics and Statistics	54	247	2.6	3.7
Physical	221	458	10.7	6.9
Social Science, Humanities and Related, Total	*1 296*	*4 283*	*62.9*	*64.9*
Arts	607	2 193	29.5	33.2
Commerce and Business	310	727	15.1	11.0
Education	223	863	10.8	13.1
Other	156	500	7.6	7.6

Source: See Table A.2.

Appendix Table A.4–Canada: Doctoral Degrees, 1961 and 1969

Field of Study	Number 1961	Number 1969	Per cent 1961	Per cent 1969
Total	**305**	**1 108**	**100 0**	**100.0**
Natural Sciences and Related, Total	*201*	*770*	*65.9*	*69.5*
Agriculture	6	23	2.0	2.1
Engineering	19	166	6.2	15.0
Forestry	0	5	0.0	0.5
Health	8	25	2.6	2.3
Science	168	551	55.1	49.7
Biological	67	181	22.0	16.3
Mathematics and Statistics	8	53	2.6	4.8
Physical	93	317	30.5	28.6
Social Sciences, Humanities and Related, Total	*104*	*338*	*34.1*	*30.5*
Arts	95	270	31.2	24.4
Commerce and Business	0	1	0.0	0.6
Education	5	48	1.6	4.3
Other	4	19	0.5	1.7

Source: See Table A.2.

Appendix Table A.5–Comparison of Graduations in Pure Science, Honours Chemistry and Physics with Immigration, Canada, 1951, 1961, 1967 and 1970

Year	1 Pure Science	2 Honours Chemistry	3 Honours Physics	4 Immigration Chemistry	5 Immigration Physics	Col. 4 ÷ Col. 1	Col. 4 ÷ Col. 2	Col. 5 ÷ Col. 1	Col. 5 ÷ Col. 2
	Number					Per cent			
1951	1 069	114	39	118	n.a.	11.0	103.5	–	–
1961	1 614	129	50	122	36	7.6	94.6	2.2	72.0
1967	4 204	178	136	751	183	17.9	421.9	4.4	134.5
1970	6 699	280	284	405	152	6.0	144.6	2.3	53.5
Average Annual Change									
1951–61 %	5.1	1.3	2.8	0.3	–				
1961–67 %	26.7	6.3	28.7	85.8	68.0				
1961–70 %	35.0	13.0	52.0	24.7	35.8				

Source: Columns 1, 2 and 3: Statistics Canada, *Survey of Higher Education*, various years. Cat. No. 81-211.
Columns 4 and 5: Department of Manpower and Immigration, *Immigration Statistics*, Information Canada, Ottawa, various years.

Appendix Table A.6–Aspects of Undergraduate Education by Current Occupation, Class of 1959, BSc (Hon.)–Chemistry or Physics–Canadian Universities

	Occupation (percentages)					
	Physical Sciences (N=47)	Manager (N=16)	University Professor (N=66)	High School Teacher (N=21)	Other (N=12)	Total (N=162)
Reason for choice of major						
High school inspiration	21.3	6.3	18.2	47.6	25.0	22.2
University inspiration	14.9	6.3	16.7	4.8	16.7	13.6
Career	10.6	31.3	16.7	19.0	16.7	16.7
Good background	2.1	6.3	6.1	0.0	16.7	4.9
Interest and challenge	36.7	31.3	28.8	23.8	25.0	30.2
Family	0.0	0.0	0.0	0.0	0.0	0.0
Other	4.3	0.0	9.1	4.8	0.0	5.5
No key reason	10.6	12.5	4.5	0.0	0.0	6.2
No answer	0.0	6.3	0.0	0.0	0.0	0.6
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
Would choose same major again						
Yes	61.8	62.5	71.2	76.2	75.0	70.4
No	31.9	37.5	28.8	23.8	25.0	29.6
No answer or don't know	0.0	0.0	0.0	0.0	0.0	0.0
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
Recommend physical sciences						
Yes	29.8	37.5	36.4	42.9	58.3	37.0
Yes, with major qualifications	38.3	37.5	36.4	33.3	25.0	35.8
No	6.4	6.3	3.0	4.8	0.0	4.3
No, with major qualifications	10.6	12.5	9.1	0.0	0.0	8.0
No answer or don't know	14.9	6.3	15.1	19.0	16.6	14.8
Total	**100.0**	**100.0**	**100.0**	**100 0**	**100.0**	**100.0**

Source: Primary research by the authors.

Appendix Table A.7–Aspects of Undergraduate Education: Comparison by Year of Graduation, Classes of 1954, 1959 and 1964, BSc (Hon.)–Chemistry or Physics–Canadian Universities

Variable	1954 (N=107) %	1959 (N=162) %	1964 (N=271) %
Reason for choice of major			
High School inspiration	26.2	22.2	24.0
University inspiration	4.7	13.6	7.7
Career	17.8	16.7	12.9
Good background	1.9	4.9	4.1
Interest and challenge	31.8	30.2	36.2
Family	0.0	0.0	0.4
Other	9.3	5.5	2.2
No key reason	8.1	6.2	12.2
No answer	0.0	0.6	0.4
Total	**100.0**	**100.0**	**100.0**
Would choose same major again			
Yes	61.7	70.4	67.5
No	33.6	29.6	31.7
No answer	4.7	0.0	0.7
Total	**100.0**	**100 0**	**100.0**
Recommend physical sciences			
Yes	34.6	37.0	24.7
Yes, with major qualifications	26.2	35.8	39.9
No	8.4	4.3	11.8
No, with major qualifications	12.1	8.0	10.0
No answer	18.7	14.8	13.6
Total	**100.0**	**100.0**	**100.0**

Source: Primary research by the authors.

Appendix Table A.8–Opinions of Physical Science Course by Occupation: Classes of 1954, 1959 and 1964, BSc (Hon.)–Chemistry or Physics–Canadian Universities

	Per cent 1954	1959	1964
Would choose same major again: yes			
Current Occupation			
Physical scientist	51.9	61.8	71.3
Manager	68.8	62.5	50.0
University professor	65.8	71.2	69.2
High school teacher	83.8	76.2	61.8
Recommend Physical Sciences: yes			
Current Occupation			
Physical scientist	18.5	29.8	21.7
Manager	31.3	37.5	35.7
University professor	44.7	36.4	21.5
High school teacher	50.0	42.9	35.3

Source: Primary research by the authors.

Appendix Table A.9–Aspects of Undergraduate Education, Classes of 1954, 1959 and 1964, BSc (Hon.)–Chemistry or Physics–Canadian Universities

	1954 No advanced degree (N=35) %	1954 Advanced degree (N=72) %	1959 No advanced degree (N=34) %	1959 Advanced degree (N=128) %	1964 No advanced degree (N=69) %	1964 Advanced degree (N=202) %
Reason for choice of major						
High school inspiration	28.6	25.0	32.4	19.5	30.4	21.8
University inspiration	5.7	4.2	5.9	15.6	7.2	7.9
Career	20.0	16.7	23.5	14.8	15.9	11.9
Good background	0.0	2.8	2.9	5.5	4.3	4.0
Interesting and challenging	25.7	34.7	20.6	32.8	34.8	36.6
Family	0.0	0.0	0.0	0.0	0.0	0.5
Other	8.6	9.7	5.9	5.5	0.0	3.0
No key reason	11.4	6.9	8.8	6.3	7.2	14.4
No answer	0.0	0.0	0.0	0.0	0.0	0.0
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100 0**
Recommend Physical Science						
Yes	25.7	38.9	38.2	36.7	40.6	19.3
Yes, with qualifications	31.4	23.6	41.2	34.4	31.9	42.6
No	8.6	8.3	2.9	4.7	11.6	11.9
No, with qualifications	8.6	13.9	2.9	9.4	2.9	12.4
No answer	25.8	15.3	14.7	14.8	13.0	13.9
Total	**100.0**	**100.0**	**100 0**	**100.0**	**100.0**	**100.0**

Source: Primary research by the authors.

Appendix Table A.10–Aspects of Education Beyond the Undergraduate Level, Classes of 1954, 1959 and 1964, BSc (Hon.)–Chemistry or Physics–Canadian Universities

	1954 (N=114) %	1959 (N=178) %	1964 (N=327) %
Graduate school – start			
Never in graduate school	23.7	20.2	17.4
Started in Canada	64.9	66.9	67.3
Started outside Canada	11.4	12.9	15.3
Total	**100.0**	**100.0**	**100.0**
Graduate school – finish			
Never in graduate school	23.7	20.2	17.4
Finished in Canada	51.8	60.1	61.2
Finished outside Canada	24.5	19.7	21.4
Total	**100.0**	**100.0**	**100.0**
Highest Advanced Degree			
None	32.5	23.6	25.1
Masters	22.0	20.8	29.1
PhD	41.2	50.6	39.7
LLB, MD	1.8	4.5	4.3
Other (diploma)	2.6	0.6	1.8
No answer	0.0	0.0	0.0
Total	**100.0**	**100.0**	**100.0**
Postdoctorate			
Had none	78.9	66.3	72.8
Broader than PhD	14.0	19.1	17.4
Narrower than PhD	7.0	9.6	6.1
Same	0.0	5.1	3.7
Total	**100.0**	**100.0**	**100.0**

Source: Primary research by the authors.

Appendix Table A.11–Specialization in Subfields at the Undergraduate Level, Graduate Level and in Current Employment, Classes of 1954, 1959, and 1964, BSc (Hon.)–Chemistry or Physics–Canadian Universities.

	1954 (N=107) %	1959 (N=162) %	1964 (N=271) %
Number of subfields at undergraduate level			
1 subfield	18.7	16.0	19.2
2 subfields	13.1	10.5	19.2
3 subfields	8.4	11.1	21.0
4 subfields	12.1	8.0	17.3
5–9 subfields	23.4	33.3	3.7
No answer	24.3	21.0	19.6
Total	**100.0**	**100.0**	**100.0**
Number of subfields at graduate level			
1 subfield	22.4	25.3	27.7
2 subfields	8.4	17.9	20.3
3 subfields	5.6	9.9	7.7
4 subfields	5.6	5.6	2.6
5–9 subfields	7.4	3.7	0.4
No answer or not applicable	50.5	37.7	41.3
Total	**100.0**	**100.0**	**100.0**
Number of subfields in current job			
1 subfield	20.6	19.1	25.1
2 subfields	8.4	15.4	23.2
3 subfields	10.3	9.3	11.1
4 subfields	10.3	6.8	4.8
5–9 subfields	10.2	14.2	0.0
No answer or not applicable	40.2	35.2	35.8
Total	**100.0**	**100.0**	**100.0**

Source: Primary research by the authors.

Appendix Table A.12–Overlap Between Subfields at the Undergraduate Level, Graduate Level, and in Current Employment, Classes of 1954, 1959 and 1964, BSc (Hon.)–Chemistry or Physics–Canadian Universities.

Subfield Overlaps	1954 (N=107) %	1959 (N=162) %	1964 (N=271) %
Graduate and undergraduate school			
None or not applicable	62.6	53.7	59.4
1 subfield overlap	19.6	21.6	24.7
2 subfield overlaps	6.5	13.6	10.0
3–9 subfield overlaps	11.2	11.1	5.9
Total	**100.0**	**100 0**	**100.0**
Undergraduate and job			
None or not applicable	59.8	50.6	54.6
1 subfield overlap	18.7	16.7	19.6
2 subfield overlaps	6.5	15.4	16.6
3–9 subfield overlaps	14.9	17.3	9.2
Total	**100 0**	**100.0**	**100.0**
Graduate school and job			
None or not applicable	66.4	50.0	57.2
1 subfield overlap	16.8	25.9	25.5
2 subfield overlaps	5.6	17.3	11.8
3–9 subfield overlaps	11.1	6.7	5.5
Total	**100.0**	**100.0**	**100.0**
Undergraduate school, graduate school and job			
None or not applicable	74.8	59.9	68.6
1 subfield overlap	13.1	20.4	21.0
2 subfield overlaps	5.6	14.8	6.6
3–9 subfield overlaps	6.5	4.9	3.7
Total	**100 0**	**100.0**	**100.0**

Source: Primary research by the authors.

Appendix Table A.13–Current Work Function, Industry, and Occupation by Year of Graduation, Classes of 1954, 1959, and 1964, BSc (Hon.)–Chemistry or Physics–Canadian Universities.

	1954 (N=107) %	1959 (N=162) %	1964 (N=271) %
Principal Function			
Consultation	0.0	0.6	0.4
Consultation – private practice	3.7	1.9	3.0
Design	0.9	0.0	0.4
Executive	32.7	13.6	9.2
Production	0.9	1.2	0.7
Research and development	28.0	40.1	42.1
Sales	2.8	1.9	3.0
Teaching	28.0	36.4	29.9
Testing	1.9	0.6	4.8
No answer, non science, medical	0.9	3.7	6.6
Total	**100.0**	**100.0**	**100.0**
Industry			
Mining	2.8	2.5	3.3
Manufacturing	24.3	20.4	18.8
Transportation, communications	0.9	0.0	0.7
Utilities	0.9	1.2	0.4
Trade, finance, service	6.5	6.8	8.5
University	35.5	44.4	41.3
High school	13.1	14.8	13.3
Government	10.3	9.9	11.4
All other, non-profit	4.7	0.0	1.5
No answer, not applicable	0.9	0.0	0.7
Total	**100.0**	**100.0**	**100.0**
Occupation			
Physical science – undergraduate field	23.4	27.8	39.1
Physical science – other field	1.9	1.2	3.3
Manager	14.0	9.3	4.1
Professor	35.5	40.7	24.0
High school teacher	11.2	13.0	12.5
All other civilian employment	12.1	7.4	15.1
Military	0.9	0.6	1.1
Out of labour force – graduate school	0.0	0.0	0.0
Out of labour force – other, unemployed	0.0	0.0	0.0
No answer	0.9	0.0	0.7
Total	**100.0**	**100.0**	**100.0**

Source: Primary research by the authors.

Appendix Table A.14–Occupation, Industry, Salary–English Canadians versus French Canadians, Class of 1964, BSc (Hon.)–Chemistry or Physics–Canadian Universities.

	English Canadians (N=234) %	French Canadians (N=36) %
Industry		
Mining	3.8	0.0
Manufacturing	18.3	22.2
Transportation and communications	0.9	0.0
Utilities	0.0	2.8
Trade, finance and service	8.5	8.3
University	40.9	44.4
High school	14.5	5.6
Government	11.1	13.9
All other employment (including non-profit)	1.7	0.0
No answer	0.4	2.8
Total	**100.0**	**100.0**
Occupation		
Physical science – undergraduate field	38.3	44.4
Physical science – other	3.8	0.0
Managerial	3.4	8.3
University professor	22.6	33.3
High school teacher	13.6	5.6
All other civilian employment	16.6	5.6
Military	1.3	0.0
Out of labour force – graduate school	0.0	0.0
Out of labour force – other (including unemployed)	0.0	0.0
No answer	0.4	2.8
Total	**100.0**	**100.0**
Salary		
$ 8 000 or less	18.7	5.6
8 – 9 999	12.8	16.7
10 – 11 999	34.5	47.2
12 – 13 999	20.4	27.8
14 – 15 999	8.1	0.0
16 – 17 999	3.0	0.0
18 – 19 999	1.3	0.0
20 000 plus	0.0	0.0
No answer	0.0	2.8
Total	**100.0**	**100.0**

Source: Primary research by the authors.

Appendix Table A.15–Key Aspects of Employment, Current Industry and Occupation, Those With or Without an Advanced Degree, Classes of 1954, 1959, and 1964, BSc (Hon.)–Chemistry or Physics–Canadian Universities

	1954 No advanced degree (N=35) %	1954 Advanced degree (N=72) %	1959 No advanced degree (N=34) %	1959 Advanced degree (N=128) %	1964 No advanced degree (N=69) %	1964 Advanced degree (N=202) %
Current Industry						
Mining, construction	5.7	1.4	0.0	3.1	1.4	4.0
Manufacturing	34.3	19.4	38.2	15.6	27.5	15.8
Transportation, communication	0.0	1.4	0.0	0.0	1.4	0.5
Utilities	2.9	0.0	0.0	1.6	0.0	0.5
Trade, finance, service	11.4	4.2	5.9	7.0	10.1	7.9
University, junior college	5.7	50.0	14.7	52.3	8.7	52.5
High School	28.6	5.6	35.3	9.4	34.8	5.9
Government	5.7	12.5	5.9	10.9	13.0	10.9
All other employment (incl. non-profit)	2.9	5.6	0.0	0.0	0.0	2.0
No answer or not applicable	2.9	0.0	0.0	0.0	2.9	0.0
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
Current Occupation						
Physical sciences – undergraduate field	20.0	25.0	20.6	29.7	27.5	43.1
Physical sciences – other field	0.0	2.8	0.0	1.6	4.3	3.0
Managerial	17.1	12.5	26.5	4.7	5.8	3.5
University professor, junior college professor	8.6	48.6	8.8	49.2	5.8	30.2
High school teacher	28.6	2.8	35.3	7.0	33.3	5.4
All other civilian employment (non-profit)	22.9	6.9	5.9	7.8	17.4	14.4
Out of labour force – graduate school	0.0	1.4	2.9	0.0	2.9	0.5
Out of labour force – other (incl. unemployed)	0.0	0.0	0.0	0.0	0.0	0.0
No answer or not applicable	2.9	0.0	0.0	0.0	2.9	0.0
Total	**100.0**	**100 0**	**100.0**	**100 0**	**100.0**	**100.0**

Source: Primary research by the authors.

Appendix Table A.16–Occupational Distribution by Year of Graduation at Selected Intervals Between 1954 and 1970, Classes of 1954, 1959, and 1964, BSc (Hon)–Chemistry or Physics–Canadian Universities.

Class	Occupation	As of September 1954 %	As of September 1959 %	As of September 1964 %	As of September 1970 %
1954 (N=114)	Physical sciences – undergraduate field	13.9	27.8	30.4	21.7
	Physical sciences – other field	1.7	0.9	0.9	0.0
	Manager	0.9	0.9	2.6	18.3
	University professor	2.6	18.3	28.7	29.6
	High school teacher	1.7	7.0	7.8	9.6
	All other civilian employment	10.4	17.4	17.4	13.0
	Military	0.9	0.9	0.9	0.9
	Out of labour force – at graduate school	57.4	16.5	1.7	0.9
	Out of labour force –other and unemployed	0.0	0.0	0.0	0.0
	No answer	10.4	10.4	9.6	6.1
	Total	**100.0**	**100 0**	**100.0**	**100.0**
1959 (N=178)	Physical sciences – undergraduate field		16.9	34.8	26.4
	Physical sciences –other field		1.1	1.1	1.1
	Manager		0.6	2.8	11.8
	University professor		1.1	16.9	36.5
	High school teacher	n.a.	4.5	11.2	10.1
	All other civilian employment		3.4	9.6	6.7
	Military		1.1	1.1	1.1
	Out of labour force – at graduate school		61.8	15.2	1.7
	Out of labour force – other and unemployed		2.2	1.7	2.8
	No answer		7.3	5.6	1.7
	Total		**100.0**	**100 0**	**100.0**
1964 (N=327)	Physical sciences – undergraduate field			11.3	28.2
	Physical sciences – other field			0.9	2.1
	Manager			0.3	3.7
	University professor	n.a.	n.a.	1.5	26.7
	High School teacher			7.4	10.7
	All other civilian employment			4.9	12.3
	Military			0.9	0.9
	Out of labour force – at graduate school			65.0	10.1
	Out of labour force – other and unemployment			0.6	0.6
	No answer			7.1	4.6
	Total			**100.0**	**100.0**

Source: Primary research by the authors.

Appendix Table A.17–Number and Type of Job Shifts: All Respondents, Classes of 1954, 1959 and 1964, BSc (Hon.)–Chemistry or Physics–Canadian Universities

Class	Shifts	Percentage of all job shifts	Percentage of employer, industry and occupation shifts	Percentage of employer, industry shifts	Percentage of employer, occupation shifts	Percentage of employer shifts	Percentage of "within employer occupational"
1954 (N=114)	1 shift	27.0	27.8	10.4	14.8	19.1	22.6
	2 shifts	21.7	5.2	3.5	0.9	13.0	12.2
	3 or more shifts	20.9	0.9	0.9	0.0	5.2	6.0
	No answer or no shifts	30.4	66.1	85.2	84.3	61.7	59.1
	Total	**100.0**	**100.0**	**100.0**	**100.0**	**100 0**	**100.0**
1959 (N=178)	1 shift	34.3	18.0	4.5	10.7	20.2	18.0
	2 shifts	14.0	2.8	2.8	1.7	5.6	2.8
	3 or more shifts	8.4	2.8	0.6	0.0	2.2	3.3
	No answer or no shifts	43.3	76.4	92.1	87.6	71.9	75.8
	Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
1964 (N=327)	1 shift	31.0	12.6	3.7	8.9	20.6	8.6
	2 shifts	10.7	2.5	0.6	0.6	2.8	0.9
	3 or more shifts	1.8	0.3	0.0	0.0	0.0	0.0
	No answer or no shifts	56.4	84.7	95.7	90.5	76.7	90.5
	Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Source: Primary research by the authors.

Appendix Table A.18–Utilization of Education on the Job, Classes of 1954, 1959 and 1964, BSc (Hon.)–Chemistry or Physics–Canadian Universities

	Percentages 1954 (N=107)	1959 (N=162)	1964 (N=271)
Undergraduate Education Prerequisite to Job			
Yes, this field	36.4	40.1	40.2
Yes, related to this field	41.1	39.5	28.8
Yes, any field	17.8	16.7	21.0
No degree required	1.9	1.9	3.3
No answer	2.8	1.8	6.6
Total	**100.0**	**100.0**	**100.0**
Undergraduate Education Useful to Job			
Considerable use	57.0	59.9	56.1
Inadequate preparation	15.0	9.9	11.1
Occasional use	17.8	14.8	11.8
No use	6.5	7.4	8.5
College generally useful	2.8	6.2	7.4
No answer	0.9	1.9	5.2
Total	**100.0**	**100.0**	**100.0**

Source: Primary research by the authors.

Appendix Table A.19–Utilization of Undergraduate and Graduate Education on the Job, by Occupation, Class of 1959, BSc (Hon.)–Chemistry or Physics–Canadian Universities

	Physical scientist (N=47) %	Manager (N=16) %	Professor (N=66) %	High school teacher (N=21) %	Other civilian employment (N=12) %
Undergraduate Education Prerequisite to Job					
Yes, this field	42.6	12.5	50.0	42.9	8.3
Yes, related field	44.7	50.0	36.4	23.8	50.0
Yes, any field	10.6	31.3	9.1	28.6	41.7
No degree required	0.0	6.3	3.0	4.8	0.0
No answer	2.1	0.0	1.5	0.0	0.0
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
Graduate Education Prerequisite to Job					
Yes, this graduate field	34.0	6.3	63.6	19.0	41.7
Yes, this related graduate field	31.9	12.5	24.2	4.8	16.7
Yes, any graduate field	4.3	12.5	3.0	0.0	8.3
No graduate degree required	17.0	18.8	9.1	28.6	16.7
No answer; not applicable	12.8	50.0	0.0	47.6	16.7
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
Undergraduate Education Useful to Job					
Considerable use	57.4	18.8	77.3	61.9	25.0
Inadequate preparation	14.9	18.8	6.1	4.8	8.3
Occasional use	12.8	31.3	9.1	14.3	33.3
No use	6.4	18.8	1.5	9.5	25.0
College generally useful	4.3	12.5	4.5	9.5	8.3
No answer	4.3	0.0	1.5	0.0	0.0
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
Graduate Education Useful to Job					
Considerable use	59.6	18.8	78.8	14.3	50.0
Inadequate preparation	19.1	6.3	7.6	4.8	0.0
Occasional use	4.3	6.3	10.6	19.0	8.3
No use	4.3	6.3	1.5	4.8	8.3
College generally useful	0.0	0.0	0.0	0.0	0.0
No answer; not applicable	12.8	62.5	1.5	57.1	33.3
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Source: Primary research by the authors.

Appendix Table A.20–Could People With a Different Educational Background do Your Job? Classes of 1954, 1959, and 1964, BSc (Hon.)–Chemistry or Physics–Canadian Universities

Class	BSc	BEng	BComm	BA	Technologist I	Technologist II	MSc (different field)	MEng	MBA	MA	PhD (different field)	PhD Eng.	PhD Management	PhD Humanities
1954														
(N=107)	percentages													
Adequately	21.5	29.0	11.2	3.7	4.7	7.5	44.9	35.5	14.0	4.7	62.6	42.1	15.9	8.4
Less than sufficiently	29.0	26.2	9.3	6.5	11.2	13.1	23.4	22.4	10.3	8.4	16.8	21.5	7.5	9.3
Inadequately	33.6	28.0	59.8	71.0	66.4	59.8	15.9	23.4	57.0	66.4	6.5	18.7	56.1	63.6
No response	15.9	16.8	19.6	18.7	17.8	19.6	15.9	18.7	18.7	20.6	14.0	17.8	20.6	18.7
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100 0**
1959														
(N=162)	percentages													
Adequately	17.3	25.9	6.2	2.5	0.6	1.9	34.0	31.5	5.6	3.1	65.4	32.1	7.4	3.7
Less than sufficiently	25.3	20.4	9.9	6.8	8.0	15.4	35.2	22.2	13.0	5.6	14.8	31.5	10.5	5.6
Inadequately	43.2	40.7	67.9	75.9	74.7	66.7	14.2	29.0	64.2	74.1	6.2	19.8	64.8	72.2
No response	14.2	13.0	16.0	14.8	16.7	16.0	16.7	17.3	17.3	17.3	13.6	16.7	17.3	18.5
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100 0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
1964														
(N=271)	percentages													
Adequately	22.9	23.2	8.5	3.3	1.5	4.8	41.7	31.4	10.7	5.5	63.1	35.1	8.9	4.1
Less than sufficiently	25.8	24.0	7.0	5.6	10.3	19.6	29.2	19.9	7.7	7.7	13.3	24.7	9.2	7.4
Inadequately	38.0	39.1	70.1	76.0	73.1	60.9	16.6	34.7	66.8	70.8	11.8	25.8	67.2	73.4
No response	13.3	13.7	14.4	15.1	15.1	14.8	12.5	14.0	14.8	15.9	11.8	14.4	14.8	15.1
Total	**100.0**	**100.0**	**100 0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100 0**	**100.0**	**100.0**

Source: Primary research by the authors.

Appendix Table A.21–Satisfaction With the Work Environment, Classes of 1954, 1959 and 1964, BSc (Hon.)–Chemistry or Physics–Canadian Universities

Aspect of the Job	1954 (N=107) Mean Value*	1959 (N=162) Mean Value*	1964 (N=271) Mean Value*
Working conditions, colleagues	81.7	79.6	81.4
Promotion, salary	79.3	76.7	74.3
Intellectual development, knowledge	79.2	77.8	77.5
Initiative, freedom	83.0	81.8	80.2
Novelty, variety	79.1	76.3	77.3
Socially useful work	73.8	72.7	68.4
Administration and planning	66.8	65.3	61.6
Opportunity to advance own effort	78.0	75.3	74.0
Confidence – scientific assignment	79.9	78.0	79.0
Confidence – administrative assignment	79.0	75.5	73.7

*The "mean value" represents a scale between 50 and 100. From 50-64 represents "hardly at all", 65-79 represents "about moderate", and 80-100, "to a high degree".
Source: Primary research by the authors.

Appendix Table A.22–Detailed Distribution, Satisfaction Scores, Class of 1959, BSc (Hon.)–Chemistry or Physics–Canadian Universities

	Working conditions, colleagues	Prom. salary	Development	Initiative, freedom	Variety	Socially useful	Planning admin.	Opport. for advance.	Scientific conference	Confidence-admin. assign.
Arbitrary Satisfaction Scale (50–100)*	Percentage Distribution									
50– 54	1.9	3.1	4.3	2.5	4.3	19.1	24.1	6.2	4.3	3.1
55– 59	1.2	1.2	2.5	0.0	0.6	2.5	5.6	3.7	1.2	2.5
60– 64	1.2	3.7	6.2	1.9	6.8	2.5	11.1	1.9	2.5	3.7
65– 69	1.9	4.9	4.9	2.5	6.8	6.2	4.9	3.1	0.0	2.5
70– 74	15.4	14.8	8.6	8.6	12.3	8.0	13.6	14.8	4.9	9.3
75– 79	11.1	19.8	8.6	6.2	12.3	6.2	11.1	9.9	9.9	13.0
80– 84	17.3	17.9	17.3	19.1	19.8	14.8	11.7	22.8	19.1	17.9
85– 89	9.9	4.9	8.6	6.2	7.4	4.9	2.5	5.6	6.8	6.8
90–100	37.0	26.5	35.8	50.6	26.5	30.9	8.6	25.9	41.4	30.2
No answer	3.1	3.1	3.1	2.5	3.1	4.9	6.8	6.2	9.9	11.1
Total	**100.0**	**100 0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

*Scores 50-64 represent "hardly at all", 65-79 "to a moderate degree," and 80-100 "to a high degree."
Source: Primary research by the authors.

Appendix Table A.23–Reasons for Declaring Physics a Major – Selected Canadian and U.S. Science Graduates

Reason	Canada, Class of			U.S.A.			
	1954	1959	1964	1	2	3	4
	%	%	%	%	%	%	%
Inspired by high school physics	28.3	21.5	22.1	13.6	14.3	12.9	13.1
Inspired by college physics	4.3	13.9	9.4	22.1	24.4	24.9	24.6
Interested in physics career	15.2	12.7	10.7	20.5	19.6	26.0	31.0
Felt physics would be good background	2.2	2.5	4.0	22.4	21.2	8.5	3.8
Interested in science and found physics challenging	30.4	39.2	38.3	7.2	4.4	8.8	12.1
Encouraged by family	0.0	0.0	0.0	2.9	4.2	3.0	5.3
Other reason, no key reason, no answer	19.6	10.2	15.4	11.3	11.9	15.9	10.1
Total	**100 0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
Number	46	79	149	390	442	193	486

Note: for U.S.A.

1 – BSc Physics holding non-physics jobs.
2 – BSc Physics in graduate school but not physics major.
3 – Graduate physic students who left before MSc.
4 – BSc Physics in physics jobs or enrolled for PhD Physics.

Source: Canada – Primary research by the authors.
U.S.A. – *Physics Manpower*, American Institute of Physics, New York, 1969. Page 40.

Appendix Table A.24–Industrial Distribution – Selected Canadian and U.S. Science Graduates

Type of Employer	Canada – BSc Honours Graduates in 1970		U.S.A. Scientists in 1966	
	BSc Hon. Physics %	BSc Hon. Chemistry %	Physicists %	Chemists %
Industry, including self-employment	22.2	32.8	28.8	57.0
Educational institutions	50.5	45.8	45.1	22.5
Government, all levels, including military	10.9	8.1	12.9	8.4
Non profit and other, no answer	1.5	2.3	4.2	4.1
Not employed, out of the labour force	14.9	11.0	8.7	8.1
Total	**100.0**	**100 0**	**100.0**	**100.0**
Number	274	345	n.a.	n.a.

Note: Includes full-time workers and others.
Source: Canada – Primary research by the authors.
U.S.A. – "Salaries and Selected Characteristics of American Scientists, 1966", *Review of Data on Science Resources*, National Science Foundation, Washington, 1967. No. 11 as quoted in W. Hirsch, *Scientists in American Society*, Random House, New York, 1968. Page 52.

Appendix Table A.25–Industrial Distribution – Selected British Science Graduates

Sector	Physics majors 1st or upper 2nd honours 1960 graduates in 1966	Chemistry majors 1st or upper 2nd honours 1960 graduates in 1966	Chemistry majors with 1958-64 PhD in 1966	Physics majors with 1958-64 PhD in 1966
Industry	30.5%	44.6%	48.6%	11.3%
Universities and Colleges	43.2	32.6	32.8	62.8
Schools	11.6	14.1	11.4	1.6
Government	8.4	7.6	7.2	24.2
Other (including 1-2% overseas but no more)	6.3	1.1	0.0	0.0
Total	**100.0**	**100.0**	**100.0**	**100.0**
Number	110	142	204	162

Source: M. Swann (Chairman), *The Flow into Employment of Scientists, Engineers and Technologists*, Her Majesty's Stationery Office, London, 1968. Pages 37, 145 and 153-54.

Appendix Table A.26–Industrial Distribution–Selected British, Canadian and U.S. Science Doctorates

Sector	**Canada** Canadian BSc Honours–Chemistry or Physics–those holding PhDs in 1970			U.K. British Scientists–First and 1966 employment of 1960 graduates with PhD or MSc		U.S. U.S. PhDs in the physical sciences in 1962	
	Class of 1954 %	Class of 1959 %	Class of 1964 %	First employment %	Employment in October 1966 %	1945–1950 cohort %	1955–1960 cohort %
Industry including self-employment	18.3	21.7	18.3	25.0	25.4	36.9	38.5
Educational institutions:							
University	58.1	63.9	68.3	48.3	49.1	39.9	34.6
Schools	2.3	2.4	0.8	8.4	7.3		
Government	11.6	12.0	9.2	11.1	8.0	7.9	10.4
All other (including overseas and not employed for U.K.)	9.3	1.2	3.3	7.3	10.1	15.3	16.5
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100 0**
Number	43	83	120	418	418	504	462

Source: Canada – Primary research by the authors.
U.K. – M. Swann (Chairman), *The Flow Into Employment of Scientists, Engineers and Technologists*, A quote taken from the Kelsall Survey, Her Majesty's Stationery Office, London, 1968. Page 33.
U.S.A. – L.R. Harmon, *Profiles of PhD's in the Sciences*, National Academy of Sciences, Washington, 1965. Page 6.

Appendix Table A.27–Functional Distribution–Selected Canadian and U.S. Physical Scientists

Function	Canada			U.S.A.			
	BSc Honours, Chemists or Physicists working as physical scientists in 1970			BSc/BA graduates from class of 1958 working in 1963, having: no advanced degree		MA/MSc	
	Class of 1954 %	Class of 1959 %	Class of 1964 %	Chemists %	Physicists %	Chemists %	Physicists %
Production, operation	0.0	2.1	1.7	18.5	7.9	6.6	2.0
Administration, executive	11.1	4.3	3.5	1.6	1.1	1.3	2.0
Research, development	74.1	83.0	80.0	74.1	82.0	88.2	81.6
All other	14.8	10.6	10.5	2.4	7.7	0.0	10.1
No answer	0.0	0.0	4.3	3.3	1.1	3.9	4.1
Total	**100.0**	**100.0**	**100 0**	**100.0**	**100.0**	**100.0**	**100.0**
Number	27	47	115	243	89	76	49

Notes: All other functions in Canada includes construction, consulting, design, teaching, sales, inspection and non-scientific functions; in the U.S.A., sales, writing, consulting, teaching and other. Canadian graduates may possess a BSc only, or advanced degrees.
Source: Canada – Primary research by the authors.
U.S.A. – L.M. Sharp, *Five Years After the College Degree*, Bureau of Social Sciences Research Inc. for the National Science Foundation, Washington, 1966.

Appendix Table A.28–Functional Distribution and Activity–Selected Canadian and U.S. Science Doctorates

Function	Canada			U.S.A.		
	BSc Honours, Chemistry or Physics who obtained PhDs as employed in 1970			Science Doctorates (including social and medical sciences) as employed in 1962		
	Class of 1954 %	Class of 1959 %	Class of 1964 %	1950 cohort %	1955 cohort %	1960 cohort %
Executive	18.6	7.2	2.5	28.7	19.8	12.5
Research and development	46.5	57.8	66.7	33.4	41.5	46.2
Teaching	34.9	33.7	25.8	28.4	30.8	33.1
All Other	0.0	1.2	5.0	9.5	7.9	8.3
Total	**100.0**	**100 0**	**100.0**	**100.0**	**100.0**	**100.0**
Number	43	83	120	1 627	1 912	2 224
Activity	Class of 1954	Class of 1959	Class of 1964	All fields	Physics PhDs	Chemistry PhDs
Still doing scientific work majority of time	69.8	75.9	70.8			
Still in field of doctorate				75.8	77.2	76.2

Source: Canada – Primary research by the authors.
U.S.A. – L.R. Harmon, *Profiles of PhD's in the Sciences*, National Academy of Sciences, Washington, 1965. Pages 5 and 16.

Appendix Table A.29–Utilization of Undergraduate Education at Work–Selected Canadian and U.S. Graduates Working as Teachers

	Canada BSc Honours, Chemistry or Physics (mostly men) working in 1970 as college teachers, from class of			U.S.A. BSc and BA class of 1958 – men working in:	
	1954	1959	1964	1960 as "College teachers"	1963 as "Teachers"
	%	%	%	%	%
A. Undergraduate education prerequisite to work					
1) Yes, this field is needed	47.4	50.0	56.9	61.2	65.9
2) Related field sufficient	39.5	36.4	27.7	19.6	15.9
3) Any field sufficient	7.9	9.1	10.8	12.7	14.5
4) No college degree needed	0.0	3.0	0.0	2.2	1.2
5) Don't know, no answer	5.3	1.5	4.6	4.2	2.4
Total	**100.0**	**100.0**	**100 0**	**100.0**	**100 0**
B. Undergraduate education useful to work					
1) Yes, of considerable use	71.1	77.3	80.0	81.9	77.4
2) Inadequate preparation	10.5	6.1	10.8	2.6	7.5
3) Occasional use	15.8	9.1	6.2	4.3	4.8
4) No use	2.6	1.5	0.0	1.0	1.4
5) College generally useful	0.0	4.5	3.1	6.5	6.1
6) Don't know, no answer	0.0	1.5	0.0	3.7	2.8
Total	**100.0**	**100.0**	**100.0**	**100 0**	**100.0**
C. Someone else could perform the work					
1) No	71.1	80.3	73.8	77.2	n.a.
2) Yes, with other formal education	18.4	6.1	4.6	6.5	n.a.
3) Yes, with less formal education	5.3	3.0	12.3	4.2	n.a.
4) Yes, with technical vocational training	0.0	0.0	0.0	0.8	n.a.
5) None of the above fits	5.3	10.6	9.2	11.4	n.a.
Total	**100.0**	**100.0**	**100.0**	**100.0**	
Total number	38	65	66	464	3 789

Note: U.S. college teachers in 1960 are probably instructors, etc., since they are only two years after the BSc/BA. U.S. teachers in 1963 are probably a mix of college and high/grade school teachers.

Source: Canada – Primary research by the authors.

U.S.A. – L.M. Sharp, *Two Years After the College Degree*, Bureau of Social Sciences Research Inc. for the National Science Foundation, Washington, 1970.

L.M. Sharp, *Five Years After the College Degree*, Bureau of Social Sciences Research Inc. for the National Science Foundation, Washington, D.C., 1966. Pages A-14 to A-16.

Appendix Table A.30–Characteristics of Their Own Jobs as Seen by Scientists, Canada and U.K.

Characteristic	University Canada	University U.K.	School Canada	School U.K.	Industry Canada	Industry U.K.	Government Canada	Government U.K.
	(Rank Order)		(Rank Order)		(Rank Order)		(Rank Order)	
Congenial colleagues and working conditions	2	3	2	2	1	1	2	1
Good salary, security, prestige and promotion prospects	7	4	4	4	3	3	4	2
Opportunities for intellectual development and increasing one's specialized knowledge	3	1	7	6	6	6	3	3-4
Scope for initiative and freedom to develop one's own ideas	1	2	3	3	2	2	1	3-4
Novelty and variety in employment	4	6	5	5	4	4	5	5
Socially useful work dealing directly with people	5	7	1	1	8	8	7	7
High level administration and planning of operations	8	8	8	8	7	7	8	8
Opportunities to rise to the top through one's own efforts	6	5	6	7	5	5	6	6

Note: Based on two different but comparable raw score statistics.
Source: Canada – Primary research by the authors (BSc Honours, Chemistry or Physics, classes of 1954, 1959, 1964, employed in 1970).
U.K. – M. Swann (Chairman), *The Flow into Employment of Scientists, Engineers and Technologists*, Kelsall Survey of the 1960 University Graduates employed in 1960, Her Majesty's Stationery Office, London, 1968, Page 89.

Appendix B – Summary of Comments

Comments by respondents were encouraged in the cover letter sent with the questionnaire (see Appendix C), but the format of the questionnaire encouraged specific comments only on questions H and I which dealt with occupational choice. General comments were made by about 10 per cent of the respondents, with the majority coming from the class of 1964. The comments on occupational choice elicited remarks from about one-third of all respondents.

General Comments

The four major themes of these comments were: the desirability of broader undergraduate education; the value of physical science education in the present career (one-half thought it was good and the remainder thought it was inadequate); supply-demand imbalance for scientists; and the need for better career and labour market information.

Specific Comments

Question H probed whether the respondent would choose the same undergraduate major again or not and question I focussed on whether or not he would recommend a scientific career to a high school graduate today (1970). Looking at these questions it is possible to come up with a rough sketch of the typical respondent who made comments. It must first be recalled, however, that only about one-third of the survey respondents commented on these questions, and the comments on question H were made almost completely by people dissatisfied to some extent at least with their undergraduate education or their occupational choice. The others, which are a majority of the survey respondents, may be generally pleased with their undergraduate education and their current work.

The typical commentator is a person who wants to work in a science field, with physical science more than likely his first preference, but the lack of jobs in his field prevents him from finding a position which he perceives to be truly satisfactory. He or she probably feels that he is underemployed in his present job, is poorly paid, lacks independence, and fails to see enough social relevance in his work.

He wishes that his education had been broader and more practical, or that he had studied in a science field which is in greater demand, such as the health sciences. He laments the fact that more career information was not provided in university.

He realizes that there are still some good jobs available in the sciences, but warns potential students of science that competition is extremely keen. However, if in view of these facts, the students still desire to study (physical) science, they should be given the opportunity.

He thinks that students should avoid undue specialization at the undergraduate level. The proper place for specialization is graduate school.

He also believes that advancement in the research areas in industry or government may be limited, and that he will have to move into management in order to obtain continuous promotions.

Appendix Table B.1–Selected Respondents from Classes of 1954, 1959 and 1964 (combined), BSc (Hon.)–Chemistry or Physics–Canadian Universities commenting on Question H: What other field would you choose if you had to do it over again?

Field	Number		Percentage	
Architecture	4		2.0	
Engineering	24		12.1	
Life Science	28	134	14.1	67.6
Health Science	34		17.2	
Other physical science, math., computer	25		12.6	
Same field but broader minors	19		9.6	
Arts, humanities	12		6.1	
Social Science	13	35	6.6	17.8
Business	10		5.1	
None	1	29	.5	14.6
Other or unknown	28		14.1	
Total	**198**		**100.0**	

Source: Primary research by the authors.
Note: Number of respondents surveyed was 619.

Appendix Table B.2–Selected Respondents From Classes of 1954, 1959 and 1964 (combined), BSc (Hon.)–Chemistry or Physics–Canadian Universities, commenting on Question H: Why would you change your field if you had to do it over again?

Comment	Response by Category Number	Percentage
Not practical, no jobs available	42	21.2
Lack of pay and independence	11	5.6
Interests have changed	42	21.2
Not broad enough, too specialized	25	12.6
Not related to current work	13	6.6
Not satisfying, relevant, socially useful	28	14.1
Other	37	18.6
Total	**198**	**100.0**

Source: Primary research by the authors.
Note: Total number of respondents surveyed was 619.

Appendix Table B.3–Selected Respondents From Classes of 1954, 1959 and 1964 (combined), BSc (Hon.)–Chemistry or Physics–Canadian Universities, recommendations to the high school graduates concerning college education in the physical sciences

Comment	Number	Percentage
Few jobs for scientists, poor salaries	87	36.5
Emphasize practical, get broad education	31	13.0
Take another science or a non-science field	5	2.1
Science education too general	2	0.8
Must be highly motivated, interested	52	21.8
Must be exceptionally talented	18	7.6
Must be concerned with meaning and purpose of science	3	1.3
Take it as a useful background to other fields	13	5.5
Choice up to individual, many factors involved	20	8.4
Others	7	2.9
Total	**238**	**100.0**

Source: Primary research by the authors.
Note: Total number of respondents surveyed was 619.

Appendix C - The Questionnaire

Synthesis - 1954/1959 + 1964
Raw Figures

All = 619
FTN's = 540
N.A. = "No answer"

CONFIDENTIAL

I. YOUR EDUCATION AND YOUR IDEAS ABOUT EDUCATION

All

A. In what YEAR and in what MAJOR AREA(S) did you receive your BACHELOR'S degree with HONOURS?

114 ☐ 1954   233 ☐ Chemistry
178 ☐ 1959   112 ☐ Chemistry & Related
327 ☐ 1964   123 ☐ Physics
   143 ☐ Physics & Related

from ______________ University
Other + N.A. = 8

All

B. To what extent was your UNDERGRADUATE EDUCATION CONCERNED with the subjects shown below? Please select ONE answer for each row or subject area.

	N.A.	Too much	Too little	Sufficiently
Your major field	15	☐ 92	☐ 54	☐ 466
Other phys. sciences	39	☐ 19	☐ 145	☐ 416
Mathematics	24	☐ 34	☐ 179	☐ 382
Technology, engrg.	104	☐ 8	☐ 243	☐ 264
Social sci., business	79	☐ 6	☐ 311	☐ 223
Humanities, languages	60	☐ 42	☐ 201	☐ 316
Other: ________		☐	☐	☐
________		☐	☐	☐

C. If you have taken GRADUATE or PROFESSIONAL WORK at university beyond the bachelor's degree, please give the details below.

University: ______________
From: ______, 19__ to: ______, 19__
Total no. of: ___courses; ___semesters/quarters
Specialty/Major: ______________
Minor fields, if any: ______________
Degree, if any: ______________, in 19___

University: ______________
From: ______, 19__ to: ______, 19__
Total no. of: ___courses; ___semesters/quarters
Specialty/Major: ______________
Minor fields, if any: ______________
Degree, if any: ______________, in 19___

University: ______________
From: ______, 19__ to: ______, 19__
Total no. of: ___courses; ___semesters/quarters
Specialty/Major: ______________
Minor fields, if any: ______________
Degree, if any: ______________, in 19___

D. If you have had a POST-DOCTORAL FELLOWSHIP (or a similar assignment), please indicate:

University/Institution: ______________
Location: ______________
From: ______, 19____ To: ______, 19____
Project (title or nature): ______________
____
(Was it ☐ broader or ☐ narrower than PhD thesis?)

E. All Please indicate the SOURCES of your FINANCIAL support at university (in a typical year):

	Undergraduate	Graduate (if any)
Work (summer; off campus)	%	%
Teaching assistantship	%	%
Research assistantship	%	%
Scholarship, fellowship	%	%
Aid from parents	%	%
Spouse's earnings	%	%
Employer contribution	%	%
Other: ________	%	%
	100%	100%

Avg. = $2,500 - 3,000

Total cost of academic year $_____ $_____
Of which educational cost $_____ $_____

F. All What was the KEY REASON for your choice of UNDERGRADUATE MAJOR? Please select ONE answer.

All

1. 158 Inspired by subject in high school
2. 57 Inspired by subject at university
3. 48 Interested in career in this field
4. 26 Felt it would be good background for another field
5. 263 Interested in science and found my major area challenging
6. 3 Encouraged by family
7. 29 Other: ______________
8. 62 No key reason; combination of factors (select if really cannot specify one)

3 = N.A.

G. All What was your approximate overall (average) GRADE in your UNDERGRADUATE years? 75.3% (Answer on basis of 0 to 100, e.g. 77, 84; if different system used, please so indicate)

H. All If you had to DO IT OVER, would you choose the SAME UNDERGRADUATE MAJOR?

1. 419 Yes
2. 206 No ... Which one instead? __________
... Why? __________

9 = N.A.

I. All In general, would you RECOMMEND PHYSICAL SCIENCE today, as a field of college study, to a high school graduate whose abilities are about the same in all subject areas?

1. 182 Yes, with little or no qualifications
2. 224 Yes, with major qualifications:
____
3. 57 No, with little or no qualifications
4. 67 No, with major qualifications:
____
5. 95 Do not know/No answer/Comment:
____

J. All How many NON-DEGREE/NON-CREDIT courses have you had beyond the bachelor's degree (e.g. short, in-plant courses), if any: ________
Comments (e.g. duration, sponsor): ________

No : 347
Yes : 272

II. THE UTILIZATION OF YOUR EDUCATION IN THE WORK YOU DO

A. How important was your education background as a PREREQUISITE for your job?

FTN'S

UNDERGRADUATE background (Select ONE answer)

24 = N.A.

1. 223 An undergraduate degree in my field of specialization is a prerequisite for my job.
2. 186 An undergraduate degree in my field, or in a closely related field, is a prerequisite for my job.
3. 103 A college degree, but not necessarily in my field, is a prerequisite for my job.
4. 14 A college degree is not required for my job.

GRADUATE or PROFESSIONAL background, IF ANY (Select ONE answer)

108 = N.A.

1. 203 A graduate or professional degree in my field of specialization is a prerequisite for my job.
2. 105 A graduate or professional degree in my field, or in a closely related field, is a prerequisite for my job.
3. 28 A graduate degree, but not necessarily in my field is a prerequisite for my job.
4. 86 A graduate degree is not required for my job.

FTN'S **B.** How USEFUL is your educational background in the performance of the work you actually do? We are especially interested in knowing how much use you make of your major and minor fields of undergraduate study and of your field(s) of graduate or professional study, if any.

UNDERGRADUATE field(s) (Select ONE answer)

18 = N.A.

1. 320 I make considerable use of my knowledge in the field(s) in which I specialized at college.
2. 62 There is need on my job for knowledge in the field(s) in which I specialized in college, but the courses I took are not the right preparation for the type of work I am called upon to perform.
3. 75 I make only occasional use of my knowledge in the field(s) I specialized in at college.
4. 42 I make practically no use of my knowledge in the field(s) I specialized in at college.
5. 33 I use many of the things I learned as an undergraduate, but not especially my major or minor fields of study.

GRADUATE field(s), IF ANY (Select ONE answer)

126 = N.A.

1. 274 I make considerable use of my knowledge in the field(s) in which I obtained my graduate or professional education.
2. 57 There is need on my job for knowledge in the field(s) in which I studied in graduate (or professional) school, but the courses I took are not necessarily the right preparation for the type of work I am called upon to perform.
3. 44 I make only occasional use of my knowledge in the field(s) I studied in graduate or professional school.
4. 23 I make practically no use of my knowledge in the field(s) I studied in graduate or professional school.
5. 14 Graduate or professional training such as I had is not relevant to my job.

FTN'S **C.** Do you feel that YOUR JOB could be DONE as well or better BY SOMEONE with an educational background DIFFERENT from yours?

1. 342 No.
2. 96 Yes, training at univ'y level or higher in fields other than the ones I specialized in would be more suitable for my job.
3. 72 Yes, the work I do in my job could also be done by someone with less formal education than I have (e.g.gen'l pass BSc).
4. 3 Yes, the work I do could probably be done better by someone with post high school, technical training, rather than the university training I have.
5. 73 None of the above fits my situation.

4 · N.A.

FTN'S **E.** Do you consider that in your current job you are doing scientific work (physical sciences) more than 50% of the time? Please check ONE.

1. 279 Yes 2. 211 No Comment: ______

N.A. = 50

D. Specifically, COULD ANY of the following PERFORM YOUR JOB? (Assume each man has same general ability you have and that he would have been hired in the first place on a trial basis). Please check ONE in EACH ROW.

FTN'S

	Quite Adeq't'ly	Less Effic'ly	Compl'ly Inadeq'ly	N.A.
B.Sc.different field	113	148	209	76
B.Engineering	136	126	202	76
B.Commerce/Business	45	45	364	86
B.Arts (humanities)	17	33	405	85
Technician I*	10	53	390	87
Technician II"	24	92	337	87
M.Sc.-physical science	216	161	85	78
M.Sc.-engineering	174	114	166	86
M.B.A. (business admin.)	53	53	346	88
M.A. (human'ts,soc.sci.)	25	39	383	93
Ph.D.-physical science	344	78	49	69
Ph.D.-engineering	192	141	122	85
Ph.D.-management	53	50	347	90
Ph.D.-human'ts,soc.sci.	26	39	384	91

(*Man with 2-year post high school training)
("Same as previous one + 4 yrs. added experience)

III. PROFESSIONAL AND WORK ACTIVITIES

All

A. Please indicate your CURRENT EMPLOYMENT status:

1. 482 Employed full-time
2. 12 Self-employed full-time
3. 30 Student full-time
4. 8 Housewife
5. Unemployed
6. 14 Retired
7. 53 Other or combination (specify) N.A. = 3

FTR's

B. Please show the approximate DISTRIBUTION of your TOTAL WORKING TIME among the different FUNCTIONS to the nearest 5% to 10%.

1. Construction, installation, erection... %
2. Consulting, private practice.......... %
3. Design, draughting.................... %
4. Executive, administrative, supervisory. %
5. Production, operation, maintenance..... %
6. Research, development.................. %
7. Sales, service, marketing, purchasing... %
8. Teaching, instructing, extension work.. %
9. Testing, inspecting, laboratory service %
10. Other functions (medical; non-techn'l) ___ %

100 %

FTR's

a. This 100% corresponds to how much time spent on your job (including work done at home)? It means 50.6 hours/week.

b. Which of the 10 functions do you designate as your principal activity? No.: ____

c. In addition to your full-time work do you consult on a part-time or summer basis?
1. 87 Yes, ___ man-days/year 2. 435 No

N.A. = 18

FTR's

C. Using the scale and the words, select a number between 49 and 99 to show the extent to which each CHARACTERISTIC is PRESENT in your JOB now.

50 — 60 — 70 — 80 — 90 — 100
hardly at all — about moderate — to a high degree

	Avg.
a. Congenial colleagues and congenial working conditions:	84.8
b. Good salary, security, prestige and promotion prospects:	79.3
c. Opportunities for intell'l develop't & increasing specialized knowledge:	81.5
d. Scope for initiative and freedom to develop one's own ideas:	85.2
e. Novelty and variety in employment (activity/function, etc.):	80.9
f. Socially useful work dealing directly with people:	74.5
g. High level administration and planning of operations:	66.5
h. Work involving communications with people as in publishing:	—
i. Opportunities to rise to the top through one's own efforts:	78.9
j. Confidence in your own ability to carry out scientific assignments:	85.2
k. Confidence in your own ability to carry out managerial assignments:	80.6

FTR's

D. How many definite JOB OFFERS did you receive (a) at the time of your graduation and (b) in the past twelve months? Please select ONE/row.

	None	1	2-3	4-5	6-8	9+
Time of grad'n	143	109	130	28	15	8
Last 12 months	327	118	92	15	6	5

N.A.

Comments, if any: ____________

FTR's

E. In the past five years, about HOW MANY of the following have you had? Indicate by NUMBERS.

Avg.
1. 6.67 Unpublished manuscripts, reports (inside or outside your organisation)
2. 3.03 Papers accepted for publication by journals, proceedings, etc.
3. .08 Books accepted for publication (including those in press now)
4. .21 Patents; or patent applications ____

FTR's

F. Please indicate by a check your MEMBERSHIP in professional associations, CONFERENCES attended in past 12 months, and scientific/professional JOURNALS regularly read. Select ONE/row.

N.A.

	None	1	2-3	4-5	6-8	9+
Association membership...	120	160	211	37	10	2
Conferences attended.....	145	161	176	37	8	10
Journals read.........	59	32	157	120	65	114

FTR's

G. Please indicate by a check the SUBFIELDS in which you specialized at university and now consider as a field of competence on the job. Please check ALL which apply.

	Under-graduate	Graduate (if any)	Current work
	Avg.	No. per	
Agriculture and food chemistry			
Analytical chemistry			
Biochemistry			
Chemical engineering			
Earth science chem'y			
Inorganic chemistry			
Metallurgy-chemistry			
Organic chemistry	2.56	1.16	1.54
Physical chemistry			
Chemistry, all other			
Atomic+molec.physics			
Astronomy			
Classical physics (acou;mech;optics)			
Elementary particles			
Electromagnetism			
Electronics			
Nuclear physics			
Solid state physics			
Thermal+fluids phys.			
Physics, all other			
N.A. or Not applicable	113	227	197

CURRENT ~~AND PREVIOUS~~ WORK HISTORY

Please provide information on each job held since graduation (B.Sc. - Honours). Start with your present job and work backwards in time. Use a separate row for each organization. Note: most of the questions can be answered by simply inserting a number. Use separate row for leave of absence, lengthy sickness, etc.

DATES OF EMPLOYMENT

Please give beginning month and year and the ending month and year for each employer

from. (month, year) — to (month, year)

NAME, LOCATION & CATEGORY OF EMPLOYER

Choose ONE number in each case and enter after name and location of each employer (see examples below)

- Primary industry (including mining) 1 16
- Manufacturing (all types)..........2 110
- Construction..........3 –
- Transportation, storage and communication..........4 3
- Electric, gas and water utilities...5 4
- Trade (wholesale and retail)..........6
- Finance and insurance..........7
- Business, community and personal services..........8 } 41
- Federal government (including defense and military)..........9
- Provincial government..........10
- Local government..........11
- Other government..........12 } 58
- University, college..........13 228
- High school, grade school..........14 74
- Other (specify below, in each case, if this applies)..........15 12

SPECIFIC JOB TITLE AND PRINCIPAL FUNCTION

If you had more than one job title with any employer please so show on same line AND indicate your major function by choosing ONE number in each case (see examples)

- Construction, installation..1 2
- Consulting, pvt. practice....2 15
- Design, draughting..........3 2
- Executive, administrative, supervisory..........4 82
- Production, operation, maintenance..........5 5
- Research, development..........6 204
- Sales, service, marketing, purchasing..........7 14
- Teaching, instructing..........8 170
- Testing, inspecting, laboratory services..........9 16
- Other (including medical, non-technical)..........10 44

GROSS ANNUAL SALARY BEFORE TAXES

Choose ONE number ea. start/ending salary

- Under $4,000..........1
- $4,000-$4,999..........2
- $5,000-$5,999..........3
- $6,000-$6,999..........4
- $7,000-$7,999..........5 } 55
- $8,000-$8,999..........6
- $9,000-$9,999..........7 } 44
- $10,000-$10,999...8
- $11,000-$11,999...9 } 122
- $12,000-$12,999..10
- $13,000-$13,999..11 } 107
- $14,000-$14,999..12
- $15,000-$15,999..13 } 94
- $16,000-$16,999..14
- $17,000-$17,999..15 } 49
- $18,000-$18,999..16
- $19,000-$19,999..17 } 24
- Over $20,000..........18 42

Starting — Ending

PRIMARY OR MAIN SOURCE OF INFORMATION USED IN LOCATING THIS POSITION

Choose ONE number in each case and enter below (see examples)

- Newspapers..........1
- Public employment service..........2
- Private employment agency..........3
- Professional/technical journals.....4
- Friends, professional contacts.....5
- Conventions and meetings..........6
- Employer contacted me..........7
- I contacted the employer..........8
- University placement office..........9
- Other (specify below)..........10

PRIMARY OR MAIN REASON FOR LEAVING THIS POSITION

Choose ONE number in each case and enter below (see ex.)

- Low pay..........1 15
- Lack of opportunity to advance..........2
- Location, climate..........3 5
- Lack of challenge..........4
- Poor supervision..........5 11
- Company's lack of growth.....6
- Low recognition of scientist.7 13
- Group layoff; fired..........8
- Poor working conditions.....9 139
- Relocation threat..........10
- Area of job interest was deemphasized..........11 6
- Company went bankrupt......12 9
- Study for advanced degree...13
- Big company; lost in group..14 156
- Lack of job freedom..........15
- Long hours of work..........16 34
- Wanted other type of work...17
- To gain more experience.....18 36

	DATES OF EMPLOYMENT from	to	NAME, LOCATION & CATEGORY OF EMPLOYER		SPECIFIC JOB TITLE AND PRINCIPAL FUNCTION		SALARY Starting	Ending	SOURCE OF INFORMATION	REASON FOR LEAVING
Example	June 1962	Feb. 1964	The A. B. C. Chemical Co., Montreal, P.Q.	2	Division Manager	4	5	7	9	6
Example	April 1956	Aug. 1966	University of Ottawa Ottawa, Ontario.	13	(1) Assistant Prof. (2) Associate Prof.	8 8	5 7	6 8	6	17
Example	May 1959	Oct. 1961	National Research Council Ottawa, Ontario.	9	(1) Chemist (2) Chief Physicist	9 6	6 9	8 10	4	13
1 Present pos'n.										
2 Prev. pos'n.										
3										
4										
5										
6										
7										

Appendix D – Multiple Regression Analysis of Salary Determinants

Multiple regression analysis allows us to measure the joint effect of a number of independent variables upon a dependent variable, in this case, annual salary. The net effect of any one independent variable on the dependent variable is calculated by holding the other independent variables constant.[1]

We are asking here, therefore, the following question: What factors explain variations in the current earnings of a given graduating class, all of whom specialized in basically the same areas? Theoretically, four major groups can be identified which explain or account for variations in the earnings of men and women similar in age and background as well as exposure to the labour force. These are quality of labour, nature of the work, organizational setting, and compensating differences. One can readily think of numerous examples in each category, e.g., productivity of the individual in the first category and profitability of the firm in the third one. Unfortunately, it is difficult to identify and to measure some of these variables in on-the-spot situations and almost impossible in a mail survey of individuals. (A survey of their employers or personal interviewing was out of the question due to staff, time and financial constraints.) In short, we often had to be satisfied with proxy variables, while in other cases so-called index or dummy variables were utilized.

An initial overview of all possible variables gave us over two dozen and ranged from academic grades (the overall average grade in the undergraduate years) to occupation (a dummy variable 1 if managerial, consulting, sales or medical position, 0 otherwise), and from size of scholarship to number of job offers upon graduation (both as possible proxies for quality of labour). In the end, we chose ten variables, described below, which were included in the analysis: but ultimately three key variables – industry, location, and satisfaction with the work environment – were those which contributed most toward explaining the variation in earnings within a given graduating class.

The results (sign and level of significance of the coefficients, the amount of explained variation or R^2, and the significance of the overall relationship or so-called F-ratio) are shown in a separate table. The significance of the net regression coefficients was tested by comparing each coefficient with its standard error. The results of the comparison are given in terms of whether the relationship (between income and the independent variable) was positive or negative and in terms of the level of significance of the coefficient of correlation or determination (e.g., being male had a positive impact on earnings and 0.99 means a 99 per cent chance that the coefficient is significantly different from zero, a result in which we can have a relatively high degree of confidence). The amount of explained variation and the significance of the overall relationship are also given for each graduating class in the table.

[1]See M. Ezekiel and K.A. Fox, *Methods of Correlation and Regression Analysis*, 3rd ed., 1959.

	1954 Class (N=107)	1959 Class (N=162)	1964 Class (N=271)
No answer	0.9	0.0	0.7
Under $8 000	0.9	4.9	17.0
$ 8 000 – $ 9 999	2.8	3.1	13.3
$10 000 – $11 999	4.7	11.7	36.2
$12 000 – $13 999	8.4	24.7	21.4
$14 000 – $15 999	24.3	30.2	7.0
$16 000 – $17 999	20.6	12.3	2.6
$18 000 – $19 999	11.2	5.6	0.7
$20 000 and over	26.2	7.4	0.7
Total	**100.0**	**100.0**	**100 0**

Source: Primary research by the authors.

Major Group	Variable	Description or Construction	Expected effect on income
Quality of labor (as seen by employers)	Sex	1 if male, 0 if female	+
Quality of labor	Advanced degree status	O if bachelor's only 1 for diploma 2 for Master's 4 for doctor's degree	+
Nature of work	Use of education	Extent to which education is used on the job, minimum score 0, maximum score 5	+
Nature of work	Substitutability	Extent to which respondent could be replaced by a person with a different background, minimum score 0, maximum score 9, (higher score for greater ease of substitution)	–
Quality of labor	Hours worked	Total number of hours worked per week, including those at home	
Quality of labor	Consulting work	1 if consults part-time or in summer, O otherwise	+
Quality of labor	Professional activity	Extent of publishing and patenting activity (1 point for each published article, 4 points for each published book, 2 points for each patent)	+
Organizational and institutional setting	Industry	1 if 'private' industry or own firm	+
		0 if 'public' sector including university, high school, hospital, non-profit organization	
Organizational and institutional setting	Geography	1 if working in U.S.A. 0 otherwise	+
Compensating differences	Satisfaction	A 'grand satisfaction index' totalling answers on ten questions dealing with the work environment (e.g. opportunity to advance, congenial colleagues, diversity and freedom etc.) minimum score 500 maximum score 999	+

Source: Primary research by the authors.

Variable or Coefficient	Sign	1954 Level of Significance*	Sign	1959 Level of Significance*	Sign	1964 Level of Significance*
Sex	+	.99	+	.70	+	.70
Advanced Degree Status	+	.85	—	.70	—	.50
Use of Education	—	.95	—	.40	+	.90
Substitutability	—	.85	—	.40	+	.50
Hours worked	+	.40	+	.50	+	.40
Consulting work	+	.40	+	.70	+	.90
Professional activity	+	.95	+	.90	+	.70
Industry	+	.95	+	.99	+	.99
Geography	+	.90	+	.90	+	.99
Satisfaction	+	.99	+	.99	+	.99
Key Indicators						
R		0.62		0.43		0.48
R^2		0.38		0.18		0.23
Fc		5.7**		3.3**		7.6**
N		107		162		271

*Higher number denotes higher level of significance.
**Level of significance greater than 0.99.

The results indicate that in each run or estimating equation (i.e., for each class), a highly significant value of the F-statistic was found; this shows the existence of a relationship between the dependent variable and the entire set of independent variables. The R^2 values, that is the amounts of explained variation, range from 18 per cent for the 1959 to 30 per cent for the 1954 class. These amounts are quite low, considering the number and nature of the variables included, and the fact of 'prior experimentation' in regard to the inclusions of other variables.

It appears that we have not been able to capture those variables in our mail survey which would contribute to a major extent toward explaining the variation in earnings. For example, it would have been highly desirable to capture specific employer characteristics, e.g., size and profitability of a business firm, pay scales of different university and high school systems, and so forth. Two of the three key variables which loom most important – industry and location – indicate the importance of organizational and institutional setting. Such variables appear to overshadow those which denote quality of labour and nature of the work. Finally, had we been able to devise more refined indices than dummy variables, and more appropriate measures for quality of labour than 'proxy yardsticks', we would have undoubtedly obtained a higher amount of explained variation.

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