

A Study of a Cohort of Ontario Engineering Students from 1955 to 1976

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Une étude qui s'est poursuivie de 1955 à 1976 nous a permis de recueillir des données concernant la formation (les stages et la formation permanente) d'un groupe professionnel: les ingénieurs. Tous nos sujets ont fait leurs études en Ontario mais un certain nombre exercent leur profession ailleurs au pays ou à l'étranger.

Nous avons utilisé des méthodes statistiques pour identifier les facteurs qui étaient liés aux programmes du 1^{er} cycle, aux caractéristiques des redoubleurs et aux motifs d'abandon. Nous avons comparé les diplômés des programmes d'ingénierie qui n'ont jamais exercé leur profession à ceux qui sont devenus des ingénieurs professionnels.

Ayant observé nos sujets, année après année, nous avons pu recueillir des données concernant leur formation permanente, académique ou autre, ainsi que leurs orientations. Ce n'est que ce genre d'étude qui peut permettre de recueillir des renseignements précis concernant les étudiants qui ont décidé de suivre un cours menant à une profession.

This article presents some of the findings of a longitudinal research project in which the educational and professional careers of certain individuals were followed from 1955 until 1976. Although the research subjects all began their undergraduate studies in the engineering faculties of Ontario universities, many are now living and working in other provinces or abroad. The longitudinal study of a complete cohort of Ontario engineering undergraduates grew out of a large-scale educational research activity undertaken more than 20 years ago by the Department of Educational Research of the Ontario College of Education, University of Toronto.¹

ATKINSON STUDIES OF THE UTILIZATION OF STUDENT RESOURCES

There had been a dearth of factual information about the aptitudes, interests, aspirations, and plans of Ontario boys and girls as well as a lack of statistical data concerning the further formal education and employment experiences of secondary school and university graduates. Such information as was available had been obtained, of necessity, from cross-sectional sample surveys rather than from long-term investigations of the career patterns of total student populations.

Ontario was very fortunate when, in 1955, the Atkinson Charitable Foundation provided a grant to enable educational researchers to make an

extended study of an entire population of Ontario grade 13 students. Dr. R. W. B. Jackson was in charge of the project. As far as is known, the boys and girls who happened to be in grade 13, the final year of secondary education, during the 1955/56 academic year were not unique in any respect. All 9573 of them were designated as research subjects for a province-wide study, over several years, of the utilization of student resources.

COLLECTION OF BASIC DATA

When the students were in grade 13, a great deal of background information was obtained about each one of them. The secondary schools made their files available for research purposes and the academic history of each student was copied from these records. Groups of teachers rated each research subject on certain personality traits such as co-operation with teachers and fellow students, reliability, and industry in school work. Also, each student completed a lengthy questionnaire about himself and his family. The questions included the educational attainments of parents and siblings, the father's occupation, and the parents' educational aspirations for their children. The students also described their own ambitions and plans for future education and employment. As an integral part of the research project, standardized tests of academic aptitude and achievement were administered. The marks earned on the province-wide final examinations in grade 13 were also collected by the researchers.

During the next few years, when many of the research subjects were attending universities, schools of nursing, technological institutes, and teachers' colleges, these post-secondary educational institutions co-operated with the researchers by making available the results of their annual examinations. Employers were also helpful in tracing former students.

PUBLICATIONS

During the decade 1957-67, a series of 13 research reports was published (Fleming et al., 1957-67). Some concern all the Atkinson research subjects; for example, Report No. 1 (by W. G. Fleming) is entitled *Background and Personality Factors Associated with Educational and Occupational Plans and Careers of Ontario Grade 13 Students*. Other reports in the series are devoted entirely to one or another of the so-called "destination groups." This term refers to the occupational or educational choice of the student immediately after his grade 13 year. An example is Report No. 13 (by Ellis, Fleming, Gill, & Savage) which focuses on those research subjects who enrolled in teachers' colleges. Generally speaking, the reports about specific destination groups compared the students in a particular group with their former grade 13 classmates and also described what had happened to the members of that particular destination group during their first few years after graduation from secondary school. By 1962, the data-collecting phase of the Atkinson Study of the Utilization of Student Resources had been completed. The findings of the research, as originally designed and funded by the Atkinson Charitable Foundation, had all been published by 1967.

LONGITUDINAL STUDIES UNDERTAKEN

Two of the destination groups, male elementary school teachers (Ellis & Stevenson, Note 1) and engineering undergraduates were selected for longitudinal studies.

The research techniques employed included both the collection of factual data about the subjects from a number of sources and occasional contact with the subjects themselves to solicit their opinions on various topics. It was desirable to locate (but not necessarily contact) each person each year. The onerous task of keeping the address list up-to-date can be illustrated by the fact that not even one person in the engineering-destination group was living at the same address when the project was completed as he had been when it was begun. Membership registries of engineering associations, university alumni mailing lists, and employers' personnel departments were consulted on a regular basis. The research subjects were co-operative in reporting address changes and in helping the researchers find others.

CHARACTERISTICS OF STUDENTS WHO ENROLLED IN ENGINEERING PROGRAMS

The 1955/56 Ontario grade 13 population of 9573 individuals had a sex ratio of three males to two females. In September 1956, 683 of the boys and none of the girls enrolled in university courses in engineering. Because statistical tests had shown that grade 13 boys were quite different from the girls on a number of personal, family, and academic characteristics, it was decided to compare the engineering-destination group with other boys rather than with grade 13 students as a whole. Tests of statistical significance such as the "t" test and the chi-square test were applied where appropriate and 1% was taken as the level of statistical significance.

What type of student chose engineering as an undergraduate program? As a group, the engineering students came from smaller families, had better-educated parents, lived in larger communities, were younger, had higher academic aptitude scores, and had higher secondary school marks than did their grade 13 male classmates. The engineering group also had a higher proportion of its members rated as "very superior" in leadership and initiative than would be expected just by chance. In general, it was found that *the students who enrolled in engineering courses were a superior group of grade 13 graduates.*

As well as comparing the engineering students with the total group of grade 13 males, the researchers compared them with certain other destination groups. The group that the engineering students resembled most closely was that of men who undertook university courses in honour arts or honour science and the group from which they differed to the greatest extent was that of young men who became elementary school teachers. It was also found that the engineering students differed greatly from the male grade 13 students who enrolled in non-university courses in technology. The latter group tended to be older, to have parents of lower educational

level, to have fewer brothers and sisters with university education, and to have lower secondary school marks than was true of grade 13 males in general. The unexpected difference between the personal and family characteristics of engineering and technology students might be related to the relative newness of technology courses in Ontario in 1956, whereas engineering courses had been established for over half a century.

ACADEMIC SUCCESS IN UNDERGRADUATE PROGRAMS

How did the 683 engineering students make out at university? *Sixty-five per cent of them graduated from engineering courses* and the other 35% withdrew without earning a degree. Because a 35% drop-out seems rather wasteful of human and financial resources, a study was made of the students who withdrew.

Why did they withdraw? The answer depends on whether one questions representatives of the universities or the students themselves! In most cases, withdrawal followed academic failure. However, the students were likely to attribute both their failure and their subsequent withdrawal to a non-academic cause such as poor health, or financial problems resulting from marriage or parenthood.

Did the students who withdrew differ statistically from the students who graduated? Indeed, they did. For example, the average age at university entrance was nearly four months younger for the successful engineering students than that for the withdrawals. Also, withdrawals were more likely to be living away from home than were successful students. A higher percentage of withdrawals had fathers who were not in the professional or managerial categories of occupational status.

A follow-up study was made of the withdrawals from engineering programs. It is rather surprising to find that the young men who withdrew from engineering courses did not enter employment in related fields. When they were contacted three or four years after leaving their engineering studies, they were found to be in such occupations as selling real estate, working as a bank teller, operating a dry goods store, and so on. Only 9 of the 239 engineering withdrawals had enrolled in technology courses and only 2 of the 9 graduated as technologists. The researchers were interested to learn that very few of the withdrawals from engineering courses expressed any bitterness about the time and money they had invested in engineering studies which they did not complete. The vast majority said that they would want their sons to go to university even if they were not able to graduate. Perhaps the embarrassment and frustration of failure fade and, after a few years, only the pleasant memories of one's university experience remain.

Although the engineering programs at Ontario universities are 4-year programs, not all who graduated spent only four years on their undergraduate work. About *one in five spent more than four years at university before graduating*. A statistical study was made of the repeaters. Comparisons were made between repeaters and withdrawals. *Repeaters differed from with-*

drawals mainly on family characteristics. They were more likely to come from families in which university graduation was the normal expectation for the sons. Of the 93 repeaters in the engineering group, 80 repeated only one undergraduate year and the other 13 repeated more than one. Because multiple repetition is in fact contrary to the regulations of some engineering faculties, the case histories of the multiple repeaters were carefully examined. They had all moved from one university to another. The most extreme case was that of a student who attended three universities for a total of seven consecutive years before earning a bachelor's degree. He came from a well-to-do family of seven brothers and sisters, every one of whom graduated from university. This again suggests the influence of family expectation on whether a failing student withdraws from university or repeats his year.

REGISTRATION AS PROFESSIONAL ENGINEERS

In Ontario, the designation "professional engineer" is restricted by law to persons who are members of the Association of Professional Engineers of Ontario. In order to practise as a professional engineer in the province, one must be licensed by the APEO. Both academic achievement and practical experience are prerequisite to registration. The usual way to become a professional engineer is to spend 17 years in formal education culminating in an engineering degree from an Ontario university, followed by another 2 years of practical experience in appropriate employment. Very few young men have had enough industrial experience either prior to university entrance or during undergraduate vacation periods to enable them to meet the APEO admission requirements immediately upon graduation; a year or two usually elapses before the graduate of an engineering course applies for registration as a professional engineer. This delay is apparent in the histories of the research subjects. Although 351 of the 444 engineering graduates were awarded their degrees in 1960 and most of the others received theirs a year later, the membership list of the APEO for 1961 included only 96 of the research subjects.

An interim report of the longitudinal research project was completed in 1968 and presented at the annual meeting of the Engineering Institute of Canada (Ellis, Note 2). It indicated that 308 of the 444 graduates — that is 69% — were licensed to practise the profession of engineering by that time. Counts of research subjects listed in the APEO directories of 1972 and 1975 confirm that graduates who do not seek and obtain registration as professional engineers within six or seven years of university graduation are unlikely to do so later on. For the past decade, the number has hovered around three hundred, the most recent count being 299.

ENGINEERING GRADUATES WHO DON'T BECOME ONTARIO PROFESSIONAL ENGINEERS

About 30% of the graduates have never sought membership in the APEO

and so are not entitled to practise the profession of engineering in Ontario. It was found that they form two distinct groups: those practising the profession outside Ontario and those who have entered other professions. The geographical mobility of engineering graduates is impressive. As the procedures of the longitudinal research project include locating each person at least once every two years, and preferably once every year, the researchers have been in correspondence with engineers in other Canadian provinces, the United States, Great Britain, Hong Kong, Australia, and so on. Graduate engineers living and working in other provinces or in other countries have usually obtained registration with the appropriate association.

Among the engineering graduates who were not practising as engineers, the most common profession was that of secondary school teaching. However, several other professions were represented. Upon graduating from an engineering course, one man re-entered university as a law student; he became a lawyer specializing in patent cases. Another man studied physiology and entered the field of medical electronics. Several graduate engineers undertook postgraduate studies in pure rather than applied science and became physicists or chemists.

In the statistical analysis, comparisons were made between those practising as professional engineers (regardless of whether they were employed in Ontario or elsewhere) and the engineering graduates engaged in other professions. Comparison criteria included personal characteristics, family background, types of schools attended, and academic achievement in secondary school and in university work. These factors were known from the basic data of the Atkinson studies. The two groups were not found to differ significantly on any criteria other than academic achievement. Both in secondary school and in university, the differences between the marks of engineering graduates who became professional engineers and the marks of those who entered other occupations are statistically significant. As an example of the research findings, consider the graduates' average marks in the final year of undergraduate work. Although the mean of the average marks of the "professional engineering" group and the mean of the average marks of the "other professions" group are almost identical, the distributions of the average marks are quite different. With rare exceptions, the members of the "other professions" group had average marks that placed them in either the lowest fifth or the highest fifth of the cases. Almost all of the graduates whose final year average marks were in the middle 60% of the cases were in the "professional engineering" group but those whose marks were in the highest 20% and those whose marks were in the lowest 20% were less likely to practise as professional engineers. What is the explanation? One must examine the postgraduate histories of engineering graduates. Many of those who were highly successful as undergraduates enrolled as full-time graduate students, often in the pure rather than the applied sciences; after earning additional degrees, they obtained employment in research work as scientists rather than as professional engineers. On

the other hand, certificate and degree courses in business administration attracted mainly engineering graduates of lesser academic achievement. Engineering graduates who went directly into a 1-year program to prepare for teaching in the secondary schools were drawn mainly from the lowest fifth of the engineering graduates.

EMPLOYMENT EXPERIENCES

In 1964, each of the 444 engineering graduates was asked to complete a 4-page questionnaire. The results of this survey were published in *Engineering Careers in Canada* (Ellis, 1969, 1970) for the information of engineering students and their potential employers. The questionnaire included items about employment experiences during undergraduate years and in years subsequent to graduation. Both factual information and expressions of opinion were sought.

Part-time employment during the academic term was not considered to be feasible for engineering students because of their heavy load of lectures and laboratory work, but practical experience during vacation periods was highly recommended. Over 80% of the respondents indicated that the value of summer work was not in technical knowledge gained but in a deeper understanding of the world of work. Typical comments were: "I had no idea of the monotony of a machine operator's day"; "If you keep your eyes and ears open, you learn a great deal about labour and management problems"; and "The foreman couldn't care less about the 'A' you got in Electrical Theory — he just wants to know how you can be so slow at splicing cables." Several of the respondents spoke highly of certain professional engineers who had taken a fatherly interest in them and helped them to make the most of the summer learning experiences.

Employment after Graduation

Of the engineering graduates who went into employment immediately after graduation, less than a fifth returned to their summer employers. By far the most common reason given by the respondents for accepting a particular position immediately after graduation was that the salary was higher than that available for other positions. The median length of time spent with the first employer after graduation was only 18 months. Why did they move? The modal reason given for changing employers was "to obtain a more challenging position or a position involving more responsibility." Salary was mentioned as important in only 5% of the changes. Are engineering graduates less mercenary after a year or two of industrial employment than they are immediately after graduation?

The 1974 Employment Survey

A study conducted in 1974 as part of this longitudinal research project concerned the number of employers the research subjects had had since graduation and the length of time spent in the employ of each one.

This study was limited to those research subjects who were entitled to practise engineering in Ontario. The number of employers (in approximately 14 years of working experience) ranged from one to six, the most common being three. A common pattern was a year or two with a first employer, then about five years with a second employer before accepting employment with a third. When subjects were asked why they had moved from the second to the third employer, salary was mentioned less frequently than was opportunity for future promotion or the opportunity to escape from what had become a routine job. Data were obtained from published materials and supplemented with information from employers and, through telephone interviews, from the research subjects themselves.

CONTINUING FORMAL EDUCATION OF GRADUATES

Preliminary information about the continuing formal education of engineering graduates was obtained from certain questions included in the 1964 survey of the 444 research subjects who had earned a bachelor's degree in engineering. From time to time, further data on this topic had become available concerning those graduates who were practising the profession of engineering in Ontario because the annual APEO directories list members' postgraduate degrees and indicate when and where they were earned. The results of tabulations made in 1967 and in 1972 are included in a paper prepared for a conference on engineering education (Ellis, Note 3). The researchers suspected, however, that not all postgraduate degrees had been reported to the professional association because this information is not required for registration purposes. Also, little was known about the continuing formal education of those research subjects who were engaged in engineering work outside Ontario or who were employed in other types of work. Therefore, the focus of the final survey of the engineering graduates, conducted in the spring of 1976, was their continuing formal education. All research subjects were to be included, irrespective of their present type of employment or location.

The success of the research team in keeping track of the subjects of this longitudinal study is exemplified by the fact that up-to-date addresses are known for 417 of the 444 engineering graduates. Over a period of 20 years, contact has been lost with only 5% of the research subjects. (It is noted with regret that five of the men are now deceased.) The co-operative attitude of the subjects themselves is illustrated by the response to the mailed questionnaire. Of the 417 questionnaires sent out in the spring of 1976, 399 were completed and returned to the researchers — the majority from subjects living in Ontario, but others from more distant parts of Canada, the United States, Europe, Africa, and Asia.

Additional Degrees

Of the 399 respondents to the 1976 survey, almost half reported that they had earned no degree other than the bachelor's degree in engineering

about 15 years ago. Of those who had obtained one or more additional degrees, 40% had done so in a field directly related to their undergraduate program. The median length of time between a bachelor's and a master's degree in engineering was four years. It was observed that engineering graduates who do not begin postgraduate studies during the first five or six years after obtaining the bachelor's degree are unlikely to do so later on. Next to the master's degree in an engineering discipline, the most common postgraduate degree was a master's in business administration. This type of degree was earned by almost a quarter of the research subjects who had obtained an additional degree. Other types of degrees earned by research subjects included bachelor's degrees in general arts, commerce, and education as well as master's degrees in divinity, arts, and education. Six of the graduate engineers had obtained degrees in law. Degrees at the doctoral level, not necessarily in an engineering discipline, were reported by 10% of those who had obtained additional degrees.

Certificates and Diplomas

The 1976 survey of the continuing formal education of the research subjects also sought information about courses they had taken which led not to a degree but to some certificate or diploma. Such programs were found to be especially popular among engineering graduates who were not engaged in the practice of engineering. Many had obtained a certificate or diploma in education before entering the teaching profession; a few had non-degree qualifications in such fields as computer programming or journalism. The certificate programs that appeared to be the most popular among research subjects licensed to practise engineering in Ontario or elsewhere were those pertaining to business administration or management techniques.

Continuing Education

In recent years, articles in technical publications and session themes at engineering conferences have stressed the growing importance of continuing education for professional engineers. It is reassuring to note that *four out of five of the subjects of this longitudinal research project report that they have undertaken some formal education since graduation*, although not necessarily for academic credit. Correspondence courses, evening courses, and short intensive courses were mentioned as well as courses provided by employers during regular working hours. In some cases the courses were sponsored by engineering associations and in other cases by employers or universities.

It is interesting to observe that as the length of time that has elapsed since graduation increases, the type of course desired by the engineering graduate gradually changes. The courses that were most popular soon after graduation were highly technical specialized courses in the person's own branch of engineering and were usually undertaken for academic

credit. Five years later when many of the men had assumed some managerial as well as technical responsibilities, part-time studies in management techniques, industrial psychology, and economics were frequently reported. Courses concerning computers continued to be popular but the nature of the chosen courses had changed from practical instruction in how to write a particular computer language to more philosophical considerations such as the influence of computer technology on modern society. By 1971, some 10 years after they had received their engineering degrees, the research subjects showed ever-widening interests. Participation in purely technical courses had declined but courses in public speaking, current affairs, oral French, and social science subjects were frequently mentioned.

Statistical tests were carried out to find on what factors those engineering graduates who did continue their formal education were different from those who did not. There was some indication that those who were most successful academically at both the secondary school and university levels were more likely to continue taking courses, but the relationship was not a strong one. It was rather interesting to find that marital status and number of children were unrelated to the likelihood of continuing formal education on a part-time basis after graduation. However, the responses to questionnaire items revealed a belief on the part of many of the subjects that such was the case. Similar findings have been noted in studies of the continuing education of other professional groups (Ellis, 1971). Some men who had not undertaken any courses since earning the bachelor's degree explained that their responsibilities as husbands and fathers had kept them too busy to do so. On the other hand, some men commented that their growing family responsibilities necessitated their keeping up-to-date through continuing formal education so that they could move as soon as possible into better-paying managerial positions.

ENGINEERS TURNED EDUCATORS

An entirely unexpected finding of this longitudinal study of an entire cohort of engineering graduates is the movement of persons trained for the engineering profession into the field of education. In 1967 it was noted that 8% of the 444 engineering graduates were employed in education and by 1972 the percentage had risen to 15. It has remained constant since that time. Which ones became educators and why? At what levels in the educational system do they teach?

Graduate Engineers Teaching in Post-Secondary Institutions

It is entirely understandable that some of the research subjects would have obtained employment as teachers of future engineers and technologists. Where else would universities and technological institutes get suitable staff other than from the ranks of graduates of engineering programs? There are research subjects currently teaching in post-secondary institutions in Alberta, British Columbia, and overseas as well as in

Ontario. These engineers-turned-educators have excellent undergraduate records, postgraduate education often to the doctoral level, and also some practical experience in industry.

Graduate Engineers Teaching in Ontario Schools

None of the research subjects has ever taught in the elementary grades. However, 10% of them are currently teaching in the secondary schools of the province. Their subjects of instruction are general science, mathematics, physics, and chemistry. Those who became teachers almost immediately after graduating from engineering usually came from the lowest quarter of graduates on the criterion of final average mark. (It should be recalled, however, that the total group was a very select one.) Those who entered the field of secondary school teaching after a few years in industry usually did so in response to some personal employment crisis such as being discharged because a department or company was closing down, being overlooked for promotion, or a personality conflict with a superior. It is rather interesting to note that most graduate engineers who expected to teach only temporarily have found that they enjoy the work very much and have decided to continue in a teaching career. One University of Toronto M.Ed. thesis is a detailed study of the 10% of the longitudinal research subjects who had become secondary school teachers (McMackin, Note 4).

COMMENT

It is unfortunate that longitudinal studies of considerable magnitude and duration are rare. In their absence, professional faculties must rely on questionnaire surveys carried out by alumni associations. An excellent example of this type of research is provided by a study of engineering graduates of the University of Toronto (Ham, Lapp, & Thompson, 1973). Unfortunately, not all graduates keep in touch with their alma mater, and it is reasonable to assume that those who do may differ significantly from those who do not. Also, the response rate to mailed questionnaires is notoriously poor. It is exceptional for alumni associations to have even a third of their questionnaires returned. Are those who complete questionnaires typical or atypical of alumni association members? The sources of bias that are inherent in questionnaire surveys of graduates of professional faculties are almost impossible to overcome except by undertaking an entirely different type of research. It is for this reason that findings derived from longitudinal studies of complete cohorts of undergraduates are of particular interest. Such studies can provide much useful information, particularly if they are carried out over extended periods of time and great care is taken to keep in touch with all the research subjects, no matter where they go or what occupations they enter.

During the first couple of years of the longitudinal study of a cohort of Ontario engineering students, the findings were of interest mainly to

secondary school guidance counsellors and persons responsible for university admissions requirements. A few years later, the information about numbers and characteristics of students who had to repeat a year or who withdrew from university was appreciated by the teaching staff of engineering faculties. By the mid-1960s, when it became apparent that about 30% of the graduates had no intention of practising the profession of engineering in Ontario, various engineering associations began to take an interest in the research. In the final decade of the 21-year project, findings concerning the career patterns of the research subjects, their movement into professions other than the one for which their undergraduate program was intended to prepare them, and the changing nature of their continuing education have attracted the interest of professional adult educators.

NOTES

This article is an adaptation of a paper presented at the Pan-American Congress on Engineering Education, Rio de Janeiro, October 5, 1976.

1. In 1965, the Department of Educational Research was absorbed by the Ontario Institute for Studies in Education. Ongoing projects of DER were taken over by OISE.

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