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EDUCATING TECHNICAL ENTREPRENEURS AND INNOVATORS FOR THE 1980'S*

THOMAS E. CLARKE

The Innovation Management Institute of Canada, P.O. Box 6291, Station "J", Ottawa, Ontario K2A 1T4 (Canada)
and JEAN REAVLEY
Stargate Consultants Ltd., P.O. Box 46167, Stn. G, Vancouver, B.C. V6R 4G5 (Canada)

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ABSTRACT

This paper examines the need for Canadian universities to supply students in science and engineering with the education necessary to understand the process involved in bringing scientific or technical ideas to commercialization. The results of a questionnaire on the subject of entrepreneurial education for Canadian students is analyzed and presented as part of the paper along with the author's solutions for handling the problems the questionnaire identified.

INTRODUCTION

This paper deals with the need to provide science and engineering university students with the necessary knowledge and skills to enable them to commercialize technical or scientific ideas.

In focussing my remarks on this limited population I do not wish to give the impression that educational opportunities in the areas of technical entrepreneurship and technological innovation management should not be made widely available to non-university students. All Canadians should have an understanding of these areas; from high school students to government bureaucrats and presidents of universities and companies. It is, however, with science and engineering students that we have the best opportunity to increase the rate of flow of profitable technological innovation in Canada.

Before proceeding any further I want to clearly define the terms "technological innovation" and "technical entrepreneur" so that there will be no confusion about the type of education being described.

"Technological innovation" is the process by which a technical idea is transformed into a product or process which has entered the market place. Thus technological innovation includes such activities as research and development; the invention stage, and marketing, finance and production as it applies to the introduction into the market place of a new product or process; the commer-

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cialization stage. Hence a "technical innovator" is the person who successfully moves a new product or process idea through these two stages and into the market place.

"Entrepreneurship" is the process by which knowhow, capital and other resources are blended together to establish a new business. Entrepreneurship does not necessarily involve technological innovation and the two terms should not be confused with each other. However, for the purposes of this paper I am confining my remarks to the process of combining technical ideas, capital, managerial knowhow and other resources to establish a technology-based company: what I call "technical entrepreneurship".

Why am I emphasizing technology-based firms and technological innovation? The answer is simple; high technology-based firms have a higher pay-off to the economy in terms of quality of employment, rate of growth and export sales than do companies in more technologically mature industries. Studies in both the United States and Canada have confirmed this greater benefit to an economy.

Canada must improve its economic and educational climate to encourage technological innovation and technical entrepreneurship. This includes both the level of understanding of technological innovation and technical entrepreneurship by all Canadians, and the quality of management of these activities. Failure to do so will condemn Canada to remaining a country that exports raw materials to maintain its balance of payments, while it imports technically sophisticated products to maintain its population's standard of living; a definition, incidentally, of an *underdeveloped* country.

Unfortunately, the role of technological innovation and in particular high-growth-potential small technology-based companies in strengthening a modern economy is at best taken for granted and at worst ignored or misunderstood by the politicians, bureaucrats and Canadians in general.

In Canada, many Canadian-owned businesses take the attitude that there is no need to build up an innovative capability because a company can always buy the needed technology. Indiscriminate use of continuing licence agreements to acquire needed technology, as a substitute for having an R&D division capable of developing its own unique products or processes, can result in a company being dependent on foreign companies for its survival. Such dependency usually stunts the company's potential for growth.

At the political level, many politicians at both the federal and provincial level fail to see the need for incentives to improve the innovative climate for Canadian industry and, as a result, fail to provide strong leadership to their bureaucrats to develop policies or programs that will effectively encourage the private sector to become more innovative. The present low percentage of our GNP spent on research and development reflects this failure.

There is also a lack of attention paid to providing appropriate training for our technical entrepreneurs and for our managers of technological innovation, and thus we rely on "inspired amateurism" while our competitors employ trained professionals.

This lack of appreciation of the need for greater understanding and improved management of technological innovation and technical entrepreneurship stems in part from deficiencies in our educational system. Canadian universities, and especially faculties of science and engineering, almost without exception, teach nothing about the technological innovation process or technical entrepreneurship; its management, and its impact on the firm and on the country. Why is this?

The answer is simple. They do not see a need to teach anything in these areas. There has been no pressure on them to provide such training, and therefore they continue to turn out graduates with a "subsidiary employment" mentality; a graduate who is ill-equipped to manage or introduce technical change or to argue effectively for technological innovation when it is warranted to ensure the long-term survival of the company.

The last thing the graduates of our universities are equipped to do by their extensive technical training is start their own business based on their own technical ideas — to be entrepreneurs.

Is the need for such training recognized either inside universities or in the business world? In 1975 I conducted a survey of Deans of Science and Engineering, to determine their views on having courses on technological innovation management included in their faculty curricula. The response was generally negative to this suggestion. At the same time I surveyed businessmen about the need for training in the area of technological innovation management, either at university or later. This time the response was generally positive, as illustrated by the following comments:

— ". . . Canadian supervisors and managers in our research laboratories should be better educated and trained in management of research". (Clarke [1975]).

— "there is a very serious lack of university training in management and business for scientific people" (Clarke [1975]).

Earlier studies of the need for R&D management training by Gishler [1973] and by Nininger and Palda [1974] of Queen's University reinforced my findings.

In the area of entrepreneurship, a study by Litvak and Maule [1972] showed that "only a few of the technical entrepreneurs possessed general management expertise comparable to their technical skills". This result was also found in another study of small high-technology businesses in Canada by Knight and Lemmon [1978] of the University of Western Ontario. They suggested that "business schools, engineering schools and science programs should be encouraged to provide courses on starting and operating a small independent business with a minimum requirement that each technical student has a project on operating his own business during his technical program". Dr M.C. de Malherbe [1976], presently Dean of Engineering at Carleton University, recommended in a position paper on industry—university cooperation that technical training should be supplemented with the teaching of business management.

In a study of technology transfer from federal government laboratories to small high technology companies, Martin et al. [1978] recommended that educational programs concerned with technological innovation management and entrepreneurship should be established for novice technical entrepreneurs. They also felt that "all government R&D staff should be given formal education in the process of technological innovation".

More conclusive evidence that there is a need for supplementing the technical training of science and engineering university students comes from a recent workshop held at York University in September of 1979. Called the T.I.M.E. for Canada Workshop (with T.I.M.E. standing for Technological Innovation Management Education), the Workshop attracted Deans of Engineering, Science and Business as well as presidents and senior managers from business. Prior to the Workshop a questionnaire was sent out to over 400 people in business, university and government. Over 150 replies were received. A preliminary analysis of some of the hypotheses and questions on the questionnaire revealed the following:

61% of the total respondents agreed with the hypothesis that "scientific and technical university graduates in Canada are not being adequately prepared for employment in industry" with 26% of these specifically focusing on the areas of business knowledge or attitude. By sector, 67% of the industrial respondents agreed with the hypothesis, while 42% of university respondents agreed.

Typical comments from those agreeing with the above hypothesis were:

—"I agree. In too many cases professors lecture from textbooks and lecture notes rather than from experience. There are two underlying reasons for this. Firstly, too few staff have been gainfully employed as engineers. Secondly, many are either doing no research or are doing research which is of a scientific rather than an engineering nature. Furthermore, faculties tend to be far too inward-looking with too little involvement with local and national industry."

– "If their goal is industrial R&D with large companies they are *adequately* trained — the company environment and training programs can fill in the deficiencies. However, they are *not* adequately trained if they are to become involved with the entire process of innovation — they have little appreciation of how a business is run, tend to directly relate technical achievement to market acceptance and have little appreciation that applied research is different from academic research — in content, attitude and purpose."

It was apparent from the replies that businessmen from smaller high-technology companies had a greater dissatisfaction with university graduates than those from large technology-based companies.

39% of the total respondents agreed with the hypothesis that "Business courses should be made compulsory in the curricula of science and engineering students", while an additional 27% considered that such courses should be electives only. In other words, 66% of the respondents

considered that such courses should be made available at least on an elective basis. By sector, 64% of industrial respondents and 74% of university respondents considered that such courses be made available at least on an elective basis.

Unfortunately, no distinction was made between technological innovation management courses and entrepreneurship courses and this would have, I believe, made a difference in the reaction to whether courses should be elective or compulsory.

Among the supportive comments were the following:

— "Agree. More "implementation of ideas" is important, and *not* only in the business courses! I have no argument with 1—2 business courses being compulsory, but any more than that should be by choice. Furthermore, if the courses are just some typical first year Commerce courses, then the concept is useless. They should be geared to the problems of an entrepreneur."

— "I think *a few* compulsory courses of this type would be useful to present to all science and engineering students some of the main aspects of business problems. Many students will have primarily technical interests and should not be forced to take large numbers of non-technical courses. Optional courses should be available to those with particular interests in business areas. I think a co-op approach with on-the-job involvement in business affairs as well as technical problems is very worthwhile."

The third hypothesis dealt with the statement that the most qualified persons to instruct university students about technological innovation management were practitioners from the private sector. Less than one in three respondents from both the industrial and university sectors agreed with this hypothesis. The biggest objection to the use of practitioners was that their teaching ability was suspect. Furthermore, the question of how many practitioners would be willing to teach was also raised. Most seemed to feel that professors should bring in successful practitioners from the private sector as guest lecturers. Some of the more interesting comments were as follows:

— "Not necessarily. While business practitioners would be likely to make a valuable input, there is a danger that they may concentrate too much on what has been or is being done rather than providing a framework which the student can use in dealing with problems in the future. The fact that a practitioner is doing (or has done) something doesn't mean that he understands why it is working, nor that he can communicate what he has done to others in a framework that will prove useful. Furthermore, unless there is an abundance of good practitioners, it is probably not a wise use of resources."

— "I agree most enthusiastically with this statement. One additional concept which I consider important is that the "practitioners from the private sector" have a track record of success. I have seen evidence of unsuccessful practitioners, apparently qualified by their years of industrial experience, but promulgating ineffectual business principles."

Two items on the questionnaire called for the respondents to suggest topics for general business courses, and technological innovation management courses. The result was the generation of two distinct lists of topics showing that at least some of the respondents knew the difference between general business courses and courses concerned with the management of technological innovation.

As a result of the Workshop, several Deans of Science and Engineering are seriously considering adopting courses on technical entrepreneurship and technological innovation management into their regular technical course offerings. Fortunately at the present time, the Technological Innovation Studies Program of the Department of Industry, Trade and Commerce is making available course development grants to encourage the development and presentation of courses on technical entrepreneurship and technological innovation management to science and engineering students.

In case you believe that the views of students have been neglected, the fact is that where such courses have been offered in Canada and the U.S., they have been well attended. A good example of this is Dr. Don Scott's course at the University of Waterloo which is designed to provide engineering students with a basic understanding of how to start a technology-based business. Demand is so great that only half the students who want to take the course can be accommodated. Even with this restriction, class sizes are in the neighbourhood of 75 students. Incidentally, Dr. Scott, along with R.M. Blair, have just recently published a text book for the course entitled "The Technical Entrepreneur". Those who have read it highly recommend it.

SOLUTION

I believe I have presented a strong case that education for prospective and practicing innovators and entrepreneurs is needed, but by what mechanism?

There are two main options, which are not mutually exclusive, that universities can adopt.

The first and easiest option is for faculties of engineering, science and business to cooperate and develop and present at least two credit courses: one in technological innovation management and the other in technical entrepreneurship, at the undergraduate level. These two courses should be general overview courses designed to acquaint the student with a basic understanding of the areas. Extension night courses could also be developed.

Based on a topic survey conducted by the Innovation Management Institute of Canada in 1976, the course on technological innovation management should cover such topics as:

- Project evaluation and selection
- Economics of technological innovation
- Technological forecasting
- Determinants of successful technological innovation
- Technology transfer: intraorganizational and interorganizational

— Assessing technical and commercial risk
— Marketing new products or processes
— Planning, controlling and scheduling R&D activities
— Supervision and motivation of R&D personnel
— Canadian climate for technological innovation

I believe that such a course should be compulsory for all science, engineering and business students.

The overview course on technical entrepreneurship, which I believe should be an elective course, should cover such topics as:

— Venture capital acquisition; initial and subsequent financing
— Preparing a business plan
— Marketing for the small technology-based company
— Financial management
— Characteristics of successful entrepreneurs
— Evaluating a prospective business
— Personnel management
— Taxation and government regulation
— Acquiring a patent
— Legal aspects of establishing and operating a small high-technology business, including incorporation procedures

If a university was interested, further in-depth courses or short seminars could be developed on any one of the topics. One of the key findings of the T.I.M.E. Workshop, referred to earlier in this paper, was that the professors presenting the courses should make liberal use of guest lecturers from the private sector, especially for the entrepreneurship course. The professor provides the anchor for the management theory and skills, while the guest entrepreneur or innovator who illustrates a success story provides the necessary role model; he/she reinforces the entrepreneurial or innovative attitudes latent in the students and provides motivation. This contribution of having a successful entrepreneur or innovator meeting with the students cannot be overemphasized; entrepreneurship, in particular, is contagious if entrepreneurial students are exposed to a live practicing technical entrepreneur.

The second option which requires a much greater commitment on behalf of the university and its faculty is to establish an Industrial Innovation Centre.

An Industrial Innovation Centre has three objectives. The first, to stimulate an increase in the quantity and quality of technological innovation carried out in a region in the form of new products or processes, or new businesses based on them; the second to make greater use of the resources contained in the university and college systems in strengthening the performance of small and medium sized technology-based businesses and in evaluating and commercializing inventions from private inventors; and third, to encourage and expand technology-based companies.

SERVICES

These objectives are accomplished by the industrial innovation centre offering the following services and undertaking the following activities:

1. Sponsoring the development and presentation of specialized courses in entrepreneurship and technological innovation to engineering, science, business or other degree-seeking students and short courses or workshop sessions to non-university "students". The university courses, both theory and laboratory, should be credit courses so that the students can "afford" to take them. These courses would develop the student's basic understanding of the innovation/entrepreneurship process and his skills in problem solving and analysis under real time business conditions.
2. Providing small and medium sized technology-based Canadian companies, students, faculty, or individuals in the community with specialized advice and assistance in the technical development and commercialization of inventions and technical ideas; to help them either expand an existing business through new product or process development, or to start up a new business; and in so doing to provide innovation centre students with live "hands on" experience in overcoming actual problems faced by innovators or entrepreneurs.
3. Providing innovators and entrepreneurs with a link with research and development resources resident in universities.
4. Conducting research on and become a centre of expertise in entrepreneurship, the technological innovation process and the teaching of these areas.

This specialized assistance referred to in the second objective might be offered in three stages: the first stage being a preliminary evaluation, both commercially and technically, to identify those five or six ideas out of one hundred that are worth pursuing. This service, for which a nominal fee would be charged, would be similar to that already being offered by the University of Waterloo and the innovation center at the University of Oregon.

The second stage would involve a more in-depth evaluation which could include a limited market or technical study. This stage would involve entrepreneurially minded students as part of their "hands on" training. The fee for this further service, which would involve some expenditure by the centre, might be a percentage of future royalties, or a percentage of stock, or bonds in a new company if the client wishes to start a company around the idea. If the stage two evaluation of the idea or invention remains positive, the client might be offered a third stage of assistance which might involve the centre investing "seed" money into the idea/invention so that it is more presentable to a venture capitalist.

The third stage assistance would also include assisting the client to prepare a detailed business plan. For this final stage of assistance, the centre would charge an additional amount in terms of either a percentage of future sales in the case of a licence or a percentage of stock or bonds in the case of a new company.

One point that should be emphasized is that the industrial innovation centres should not unnecessarily duplicate any existing local services to entrepreneurs, businessmen or inventors but should try to act as a local agent for such services, if that is possible. The centres will endeavour to become comprehensive assistance centres for technology-based firms or inventors.

An important aspect of these centres is who would control them. Although the industrial innovation centres must work very closely with a host university and, in particular, with the faculties of engineering, science and business, the centres should not be controlled by their host university. One important lesson that can be learned from observing the American experience with their innovation centres is that the centres should be, from the beginning, federally incorporated non-profit entities.

There are four main reasons for this:

1. The centres should have as much independent decision-making authority as possible and be free of the bureaucracy and reward structure of the host university.
2. Since the centres are dealing with business matters, they should have the protection of limited liability.
3. As a separately incorporated entity they are more likely to adopt a business outlook for the centre activities.
4. The centre will be free to recommend any source of assistance or help in the community or in Canada, for that matter, and not be tied to any one source.

The Board of Directors of a centre should be a working Board with most of the Directors being people who have actually gone through the process of starting a high technology-based business or of launching a new product or process. Other Board members should be drawn from government and academia. The Board of Directors must have a strong influence on the operating policies of the centre, ensuring that the activities of the centre are directed toward the practical needs of both students and industrial clients in the region.

Whereas the first option of simply presenting courses would be evaluated on the basis of the number of students taking the courses, the Industrial Innovation Centre's performance should be judged by the following criteria:

1. Number and sales value of new products or processes successfully developed;
2. Number of successful new businesses started;
3. Number of jobs created or saved;
4. Number of businesses assisted, with the economic results documented;
5. Number of university graduates, who have taken centre courses, involved in small technology-based businesses after graduation;
6. Number of students taking centre courses;
7. Number of seminars or workshops presented to businessmen in the community;

8. Number of research reports on technological innovation and entrepreneurship produced and published; and
9. The degree to which the centre is moving towards becoming self-financing.

CONCLUSION

I would like to conclude by saying that Canadian universities have an important role to play in increasing the public's awareness of the impact of technological innovation on the economy and in improving the quality of management of technological innovation and technical entrepreneurship. If they fail to accept this role as part of their educational mandate, if they maintain their aloofness from the business world, then I would predict a very gloomy future for Canada. Universities must face the realities of the 1980's and not act as if this were still the 1880's. They must be a contributor to the educational needs of tomorrow's industrial scientists and engineers, not yesterday's.

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