EDUCATING ENGINEERING STUDENTS IN ENTREPRENEURSHIP

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ABSTRACT:

Since it's founding in 1865, the faculty, students, and alumni of Worcester Polytechnic Institute have been responsible for the establishment of nearly all the manufacturing industry in the region. Beginning with the Norton Company, a world-wide abrasives manufacturer now owned by Saint Gobain, to recent biotechnology companies, they have combined confidence, innovation, and resourcefulness to continuously accomplish what is now referred to as technology transfer to form start-up companies. By following the historical development of these firms, we seek to determine some of the traits and environmental factors that have fostered the continual entrepreneurial success of the founders.

Worcester Polytechnic Institute was founded by leading industrialists to provide graduates trained in the mechanical arts in order to support the burgeoning manufacturing community of the North American industrial revolution. The educational philosophies of the two principal financial contributors were substantially at odds: one believed that the traditional "book-learning" as practiced in many of the early American universities would be the appropriate curriculum while the other believed that a hands-on apprenticeship in a workshop environment would be more suitable. As it turned out, each financed the construction of a major building; one to provide classroom instruction and the other mechanical shops and laboratories. This theory and practice philosophy still prevails today and was also adopted by such colleges as Rose-Hulman, Illinois Institute of Technology (formerly Armour Institute) and Georgia Tech.

From the beginning, WPI students conducted independent research and development projects embodied in a senior thesis requirement until 1970 and in the Major Qualifying Project, one of the primary degree requirements, subsequently. Students and faculty work together to solve open-ended projects derived from real problems of industry. It will be argued that the technological self-reliance, active learning, and discovery embodied in such projects promote entrepreneurship. Examples will include: Wyman Gordon, automotive and aircraft forging; Morgan Construction, steel mills; Alden Research Laboratory, hydraulic research; Jamesbury Corporation, ball valves; Viva Scan, biomedical sensors; NASA, the area/drag rule development and DEKA, the stair climbing wheelchair.

INTRODUCTION:

Founded in 1865 Worcester Tech, later called Worcester Polytechnic Institute and now WPI, was conceived as an institution of higher education whose purpose would be an endless quest for answers to the mysteries of engineering and science. Simultaneously, it was to provide for a richer material life for its students, faculty, alumni, and the developing communities of central Massachusetts. Although not directly stated in its charter, entrepreneurship was an implied but not explicitly stated goal. The early curriculum was designed to foster the development of entrepreneurial activities by the students, which were often initiated and encouraged by the faculty. The result was the start-up of many local enterprises by Worcester Tech graduates whose program of study included participation in the Washburn Shops, a profit making operation dealing with the manufacture of drawing stands for high schools and colleges.

Engineering education at WPI with its theory and practice focal point through the Washburn Shops became a model for the engineering programs of Rose-Hulman, Illinois Institute of Technology (then known as Armour Institute of Technology) and Georgia Institute of Technology. The active role of the Washburn Shops as a profit oriented educational tool had its share of controversy. The implication that faculty members were spending more time on the development of their own products than they were on educational endeavors did result in the resignation of some faculty members who left to form new companies. A well-known example is the Norton Company (now Saint Gobain) the world's largest manufacturer of abrasive grinding wheels.

In its early stages, the entrepreneurial activities at WPI resulted in enterprises based on mechanical devices. A review of senior theses, a degree requirement for all students until shortly after WWII, and the WPI Alumni Journal shows alumni becoming involved in the development of the automobile, steel mill construction, textile machinery and the aircraft industry, for example. As science and technology had changed so has entrepreneurship. Mechanical devices were supplemented by biomedical instruments, computer software and hardware, electronic devices, and space technology. While entrepreneurship was formerly an implied learning process it was replaced in part by formal programs both on and off campus. The formation of the Management Engineering Department, a new degree program started in 1965, and the Venture Forum are prime examples.

OBJECTIVE:

This paper emphasizes the undergraduate program of WPI and the relationship of its educational programs to the development of entrepreneurs. Examples of entrepreneurship are discussed, as are the benefits that have resulted from a program, the WPI Plan, to emphasize the benefits of entrepreneurs.

INTERMEDIATE:

In the early days of WPI the senior thesis was the primary way in which students became aware of the characteristics of an entrepreneur. The hands on approach of the Washburn Shops, the mentoring and examples of faculty members, and the formation of small companies, primarily in central Massachusetts and New England were also examples.

The program of study for the engineering students dealt with "how" as much as "why". Curricular changes were minimal and evolutionary. Fundamental research was seldom coupled with classroom teaching. The local industries which had their start from "far out" thinking were now characterized as was the curriculum by interpolation in contrast to extrapolation of new methods, devices and experiences as entrepreneurs. There were however, notable exceptions but industries and academic programs were coupled with a national economy that ranged from favorable to crucial and did not stimulate the dreams needed by entrepreneurs. Applications of technology and professional practice were emphasized as the alternative to the development of scientific literacy. This plateau of entrepreneurship in the engineering programs of WPI began to shift in the later 1930's and early 1940's as the political climate around the world burst into WWII in 1939.

THE WAR YEARS:

Historically, wars have been the catalyst for the activities of entrepreneurs. Results dictate that new technologies be introduced and talented entrepreneurs flourish. At WPI's Alden Research Laboratories students and engineers worked as a team dealing with acoustic noise in submarines. The aeronautical laboratories worked on improving performance of aircraft propellers. The electrical laboratories were involved with radio communication, and faculty emphasized ingenious methods of utilizing scientific principles in war related efforts ranging from fire fighting equipment for ships to increased power of aircraft engines. Robert H. Goddard who was known in later years for his early theoretical and experimental work in rocketry was able to use his knowledge of liquid propellants to develop the first jet assisted take-off (JATO) for aircraft.

For the students at WPI this was an exciting and rewarding stage of their lives. The technical challenges afforded them, along with the developing technologies available, enabled them to work on projects of previously unheard significance. Their ingenious solutions to problems were often the foundations for new companies. Jamesbury Corporation, based on clever geometry for sealing ball valves, is an example. Concurrently, the students who went into military service or industrial employment were given responsibilities involving people, machines, and business along with the opportunity develop skills needed as an entrepreneur. Nevertheless, the educational program of WPI, similar to most other colleges of engineering involved some course evolution but minimal changes in the teaching/learning methodologies.

THE ROOTS OF CHANGE:

At WPI, the decade following WWII was one of business as usual. Minimal academic changes were implemented. The college was struggling just to meet critical resource requirements for students and faculty at the same time that the local and national gross domestic product did not provide for discretionary undertakings. There were, however, faculty at WPI and many other engineering colleges who utilized their enterprising spirit to lay the groundwork for significant reform in engineering education. Nationally, through the auspices of the American Society for Engineering Education a report entitled "Goals of Engineering Education" was published in 1955. The report urged that

engineering colleges follow one of two academic stems, professional scientific or professional vocational. (The Executive Director of ASEE at this time was Prof. Arthur B. Bronwell of Northwestern University who became President of WPI in 1955.) Controversial dialogue at every engineering college, technical society, and accreditation agency in the United States followed. Seeds of curricular change had been planted!

The implementation of curricular change in the United States was necessitated for another reason as well. When the USSR announced the orbiting of "Sputnik" around the earth the United States had to meet the challenge and few, if any, engineering colleges were ready in either a technological or an entrepreneurial sense. WPI was no exception.

In an academic sense the next two decades at WPI were involved with entrepreneurial educational undertakings of a magnitude that, had failure of the program resulted, the existence of WPI as a technical university would be questioned. Engineering education was stagnant, national needs were unmet, and economic development needed connection to innovation.

EDUCATIONAL ENTREPRENEURSHIP, THE WPI PLAN:

In the late 1960's there was an increasing dissatisfaction with the rigidity of the traditional curriculum and the way in which it minimized entrepreneurial efforts of students and faculty. The rigid academic program did little to encourage personal self-development necessary to undertake professional responsibilities immediately after graduation. Classroom experience was largely information transfer, a very passive learning process. Each student was essentially an isolated learner and thus did not develop personal interaction skills, shared learning experiences, or the oral and written communication skills associated with effective professional practice.

During the same time the faculty recognized the need for a different engineering graduate, one who could combine engineering, business, economics, and government. In 1965 a new Management Department was approved. A major objective was to foster the education of would-be entrepreneurs.

In 1970 following two years of intensive study and planning the resulting report, the WPI Plan, was approved by the faculty and the trustees. The WPI Plan called for the award of a Bachelor of Science degree upon the demonstration of competence involving four-degree requirements.

1. A qualifying project dealing with a problem in one's major area of study (1/4 year equivalent)
2. A qualifying project relating science and technology to societal concern and human needs (1/4 year equivalent)
3. A sufficiency (minor) in an area of the humanities (1/2 year equivalent)
4. A competency examination in the major field of study (1 week duration)

The program involved an approach to engineering and science education, which promoted the concept of an individualized curriculum for each student. Heavy emphasis was placed on project-based learning and accomplishment and became the basis for the Global Perspectives Program of WPI. There were no specific course requirements but a minimum of three years of successful academic work was required before the competency examination could be scheduled. Each student, in concert with a faculty advisor became an academic entrepreneur. The lockstep policy of the rigid curriculum was eliminated. Each faculty member now became the academic advisor, or coach, for an individual student.

In its formative years the Plan was reviewed by nationally known educators, government specialists, members of industry, the National Science Foundation, accreditation agencies such as ABET, and consultants from Harvard and other institutions. The evaluations were very positive. Evolutionary changes in the Plan have taken place in the three decades of its existence. The formation and execution of the Plan, including the administrative changes, was considered by many engineering educators as the most entrepreneurial undertaking by any educational institution.

There was, in addition, another critical change taking place concurrently. Until 1970 WPI was basically a male school when women students were admitted as undergraduates. Today, more than 20% of the students are women. This percentage corresponds closely to national engineering data.

PROJECTS AND ENTREPRENEURS:

In the early years of WPI starting in 1865 many local and regional industries were developed by the graduates. The Norton Company, Wyman Gordon, Morgan Construction and Coghlin Electric are early companies, which still exist today and have consistently supported WPI. The fields these companies covered were, respectively, abrasive grinding wheels, automobile and aircraft forgings, steel mills, and electrical systems and supplies. Elwood Haynes, a WPI student, was the founder of the Haynes Electric Automobile Company.

In the middle years of the history of WPI entrepreneurs still flourished but at a much slower pace since the region became dominated by large metal working/producing companies. Very few of the companies originally formed during this period by students or faculty are still in active operation.

World War II gave impetus to entrepreneurs and many new companies spun-out of WPI through technology transfer. Examples include the Press Met Corporation (powder metals), Rockwood Sprinkler (fire protection systems) and Jamesbury (ball valves). These companies were successful and are currently in operation and closely tied with the university.

The pre-PLAN curriculum produced a number of corporate leaders including Stemple at General Motors, Allaire at Xerox, Smith at United Technologies, and Whitcomb at NASA.

With the formation of the Engineering Management program of 1965 and the WPI Plan in 1970, the development of an entrepreneurial activity by the faculty and the graduates increased. Faculty became national presidents of ASEE (Cranch) and ASME (Zwiep) and the Alden Research laboratories became a private company (Hecker). Robert and Karen Bean formed Bay State Technologies, now CAD-KEY and Dean Kamen formed DEKA and is known for medical instrumentation, a stair-climbing wheelchair, and the FIRST program. Finally, WPI faculty, students and graduates are key players in the region's biotechnology industries. Local start-up companies include VIACELL, BASF Research Corporation, ORIGENIX, ANTIGEN EXPRESS, BIOPAL, BIODYNAMICS LUXTEC, STEREOCHEN, Q-ONE, and EXPRESSIVE CONSTRUCTS.

Many other examples could be listed. However, WPI students and faculty are now engaged in enterprises ranging from microbreweries to medical instrumentation, from nanotechnology to large-scale structures, from space to deep-sea exploration, and from politics to religion. The innovative educational experiment of the faculty in 1970, the WPI Plan, is a successful model for 21st century technical education.

SUMMARY:

Starting in 1865 the graduates of WPI were instrumental in the formation of successful enterprises of the local and central Massachusetts communities. The senior thesis, a personal technical project, was a principal mechanism for the development of entrepreneurs among the students. Faculty members often left WPI and formed their own companies since unwritten school policy did not encourage their entrepreneurial bent.

In the middle years of WPI history entrepreneurial pursuits from both students and faculty was less evidenced. The program of study was more rigid and developmental activities much less. As WWII approached the new need of industry again fostered entrepreneurial endeavors through the formation and operation of local and regional organizations.

In 1965 WPI made a major improvement in entrepreneurial education with the formation of the Management Engineering Department. Concurrently, faculty discussions brought out the need for less rigidity in the academic programs and led to the formation in 1970 of the WPI Plan and its time independent, course independent degree requirements. The Plan was a catalyst for independent thinking and the development of students with entrepreneurial skills. WPI graduates are now forming new companies in diverse areas of technology. The program changes brought about by the Plan via usual academic assessments are successful and are a model, particularly the projects, for other academic institutions and global education.

CONCLUSION:

A major reason for the formation of WPI was to graduate students who could be leaders in the growing manufacturing community of central Massachusetts. This leadership necessitated the skills to fill managerial positions in developed companies and to participate in the formation of new ones. The graduates were highly successful in both regards. Two academic requirements, hands-on experience in the Washburn Shops and the senior thesis, were utilized to develop an entrepreneurial spirit in the WPI community.

In the middle years of WPI's history or until WWII the entrepreneurial side of WPI's educational program exhibited minimal changes. However, external factors such as WWII and the Space Age coupled with a desire for curricular changes by the faculty brought about a new program, Management Engineering, and later, 1970, the WPI Plan.

The Plan has been highly successful in fostering a new breed of entrepreneurs. The development of new companies by graduates and faculty has ranged from outer space garments to biotechnology. Entrepreneurial activities have been a success story of the Plan.

Selected References: This is not a bibliography. Rather, it notes sources to which specific reference could be made as well as sources where help was less tangible.

1. Herbert Foster Taylor, "Seventy years of the Worcester Polytechnic Institute", published at WPI, 1937
2. Mildred Tymesson, "Two Towers, the Story of Worcester Tech", published at WPI, 1965
3. Grogan, Scott, Demetry and Peura, "The WPI Plan, A New Approach to Education", Worcester, Massachusetts, 1971
4. Zwiep and Massie, "Educating Engineering Students for Global Social Responsibility", World Conference on Engineering Education, Oct. 15-17, 1995, Saint Paul, Minnesota
5. American Society for Engineering Education, "Final Report of the Goals of Engineering Education", January, 1968
6. "Worcester Telegram and Gazette, "Management Engineering at WPI", February 23, 1964
7. Metz, "A College Throws Out the Curriculum", Wall Street Journal, October 2, 1970
8. Gehret, "Free But Accountable. Engineering Students Chart Own Course", Christian Science Monitor, January 16, 1971
9. Durgin and Zwiep, "Global Projects Prepare WPI Students for the 21st Century", 3rd Workshop on Global Engineering Education, Aachen, Germany, October 18-20, 2000
10. Mancuso, "Envy the Entrepreneur?", The Saturday Evening Post, May/June, 1978
11. Zuckerman, "A World Out of Balance", WPI Journal, Summer, 1989