The proposed PhD in Technology Management at the University of Bridgeport: a case study

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Abstract: Most schools of engineering and business today have not yet come to terms with the growing inter-disciplinary education needs that adequately prepare PhD graduates for assuming leadership, professional, academic and/or research positions in academia, industry or government. The purpose of this paper is to contribute to a better understanding of how to develop an innovative inter-disciplinary PhD degree programme by presenting a case study in technology management at the University of Bridgeport. The proposed PhD programme is currently undergoing an external review process. The paper will describe the purpose, structure, and approach of the proposed PhD programme as well as the challenges, lessons learned and critical success factors.

Keywords: technology management; TM; management of technology; entrepreneurship, technology concentrations; interdisciplinary education; graduate programmes; PhD.

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1 Introduction and background

The University of Bridgeport is a private, doctoral-intensive university, offering a variety of undergraduate and graduate degree programmes to a student body of over 5,000 people representing more than 80 countries. The School of Engineering is the largest in the State of Connecticut and offers undergraduate degrees in Computer Science and Computer Engineering, master's degrees in Technology Management, Computer Science, Computer Engineering, Mechanical Engineering, Biomedical Engineering and Electrical Engineering and a PhD in Computer Science and Engineering.

The Technology Management (TM) department, part of the School of Engineering, has grown from 32 students to over 150 students over the past six years and is the largest in Connecticut and New England. The department offers an MS in Technology Management with several professional concentrations. Worldwide, Engineering and Technology Management (ETM) has been growing rapidly, with the number of institutions offering programmes expanding from 32 in 1976 to over 160 currently (Alvear et al., 2006).

Based on our success with the MS in TM programme, along with strong support from UB's Industry Advisory Board, we explored the feasibility of developing a flexible inter-disciplinary PhD programme in Technology Management. This paper represents a case study at the University of Bridgeport and describes the purpose and structure of the proposed PhD programme.

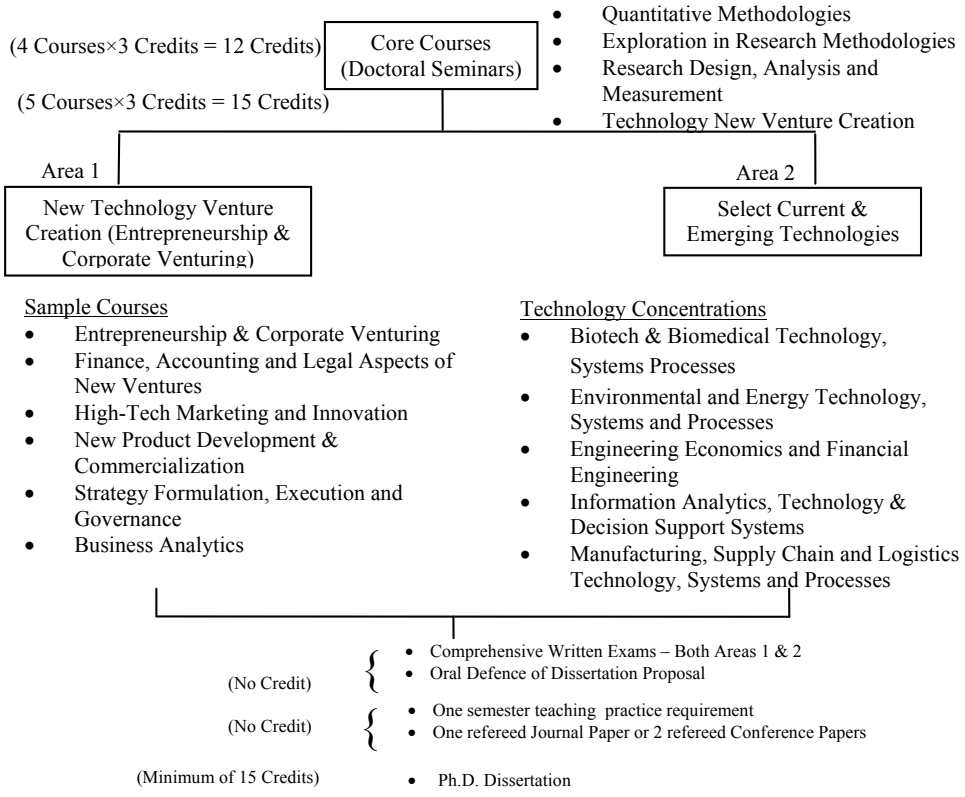
2 Literature review

Science and engineering (S&E) are two disciplines that are highly receptive to the changes in demand for products and services and both have the responsibility to be compatible with the emerging needs of the market (Kongar et al., 2010). This fact is also true for the institutions awarding science and engineering degrees. Educational institutions often initiate programmes to be compatible with the current industry and academic requirements. Even though the topic is very important for the technological competency of the USA, the literature concentrating on engineering PhD programmes is very limited (Steenhuis and de Brujin, 2011). Existing studies that deal with doctoral education mainly focus on student supervision. One of these studies is published by Mainhard et al. (2009) where the authors discuss the relationship between the supervisor and the PhD student and explore ways to improve communication. Steenhuis and de Brujin (2011) aimed at analysing PhD education and tried to depict the problems from the supervisor's perspective. The authors categorised the problems into three: student's ability to conduct independent research, abstract thinking abilities, and communication

skills. Wiles et al. (2009) concentrated on the training and supervision of research students and identified the need to narrow the gap between early-career researchers' skills and employers' needs. Emphasising the importance of supervision, Egan et al. (2009) conducted a comprehensive survey among PhD students and concluded that a personal and holistic style of supervision was needed to obtain maximum benefit from their graduate studies. Supporting this argument, Whitelock et al. (2008) published that a well-established relationship between the student and the supervisor would aid in the development of academic creativity in doctoral studies. Furthermore, efficient interaction between the supervisor and the supervisee play an important role on the induction of the supervisee into the academic community (Kumar and Stracke, 2007). Kolmos et al. (2008) also focused on the significance of PhD student supervision, especially for those who were physically placed in companies for a large part of their study time. The authors mentioned that the industry PhD students benefit greatly from having two supervisors; a company supervisor and a university supervisor.

Manathunga and Lant (2006) list the required skills for PhD graduates as 'problem-solving and problem-formulation', 'communication skills', 'project management skills', industry focus, understanding and applying multiple disciplinary and international perspectives', 'high quality research skills', 'expert integrated knowledge' and 'social, ethical and environmental responsibility'.

Figure 1 PhD in Technology Management programme outline



In addition to the studies discussing various criteria to ensure a PhD programme's success, the literature also embodies a small number of publications that concentrate on establishing new PhD programmes in engineering and related disciplines. Among these, Akay (2008) focused on the doctoral education and its role in the USA and addressed universal issues regarding PhD degrees in engineering. Katehi et al. (2003) proposed a framework for a new School of Engineering Education under the School of Engineering at Purdue University. Poler et al. (2006) described the overall structure of a new interdisciplinary PhD degree in 'Nanoscale Science' at UNC Charlotte and compared the programme with similar graduate education efforts throughout the USA.

The literature review, accompanied by the contacts with students, faculty, industry and other educational institutions led to the introduction of new PhD. specific courses into the core PhD curricula (Figure 1).

3 Market need and industry/academic support

We identified a shortage in the market for inter-disciplinary degrees covering both technology and management of new technology ventures. The Science and Engineering Indicators Report 2010 published by the National Science Board (2010) identified a number of relevant trends:

- "Industries that rely heavily on the application of knowledge and technology are driving growth in manufacturing, information and communication technologies, bio-technology and services."
- "The global nature of these developments compels governments to take part in them or be left behind, to the detriment of a country's economic standing and well being. Growing markets, including rapidly expanding ones in Asia, beckon, especially for knowledge- and technology-intensive goods and services."
- "Countries are investing heavily in expansion and quality improvement of their higher education systems, easing access to them, and often directing sizeable portions of this investment to training in science, engineering and related fields. Countries are promulgating policies to strengthen domestic science and technology capabilities so as to become less reliant on foreign expertise."
- "A knowledge intensive economy (like the USA) requires skills of science and technology trained persons in a wide range of sectors and positions."
- "Advanced training in natural sciences and engineering is becoming widespread (globally), eroding the US advantage."
- "Many of the new technologies and industries seen as critical to US economic growth are also closely identified with small businesses such as biotechnology, the Internet and computer software."
- "According to Census Bureau Data, US small businesses operating in high technology industries numbered nearly one-half million firms and employed 5 million workers in 2004."

- "Key industries that have attracted the largest share of Venture Capital funding in 2005–2006 are: computer software, biotechnology, the Internet, communications, healthcare and semiconductors."
- "The US economy continues to be a leading competitor and innovator as measured by its overall performance, market position in science and technology industries and trends in patenting of new technologies. Several Asian economies, however, including China, South Korea, Taiwan and India, have become global players in some high-technology industries."
- A growing body of knowledge (Burgelman, 1988; Block and MacMillan, 1993; Albrinck et al., 2001) and articles appearing in Harvard Business Review (Olson et al., 2008) are devoted to the need for new corporate ventures in a growing number of business and technical fields to enable business and technology innovation, growth, and competitive survival.

The Department of Economic and Community Development for the State of Connecticut is focusing on nurturing and growing key state industries to improve the competitiveness of businesses within key industries, in turn creating jobs and improving the Connecticut economy. We believe that the PhD programme will help key industries by focusing on new technology venture creation and entrepreneurship in areas related to some of Connecticut's key industries.

At Georgia Institute of Technology, the Colleges of Management and Engineering are working together to meet the growing corporate need for graduates who can succeed on inter-disciplinary teams in industry. According to a report by the National Science Foundation (2011), graduate enrolment in science, engineering and health fields in the USA has grown from 493,311 in 2000 to 631,645 in 2009, an increase of approximately 30%. The US Bureau of Labor Statistics (2011) reports the total number of engineers employed (in all engineering categories) in 2008 was 1.57 million while engineering employment in 2018 is projected to be 1.75 million, an increase of 11.5%. The interest and the demand for trained technical professionals are strong in the USA.

UB has an Industry Advisory Board consisting of over 25 external organisations (including representatives of major US corporations). We received 28 letters of support for the proposed PhD programme from these organisations. We also received eight support letters from select domestic and international universities. Over 20 current Masters students at UB supported the programme and indicated that they would enrol in the PhD programme if it were offered today.

Alvear et al. (2006) analysed 142 universities offering degree granting programmes in ETM worldwide in terms of programme characteristics, courses offered, degree granted, faculty, and research areas. The major findings and conclusions of the study are summarised below:

1 The number of programs and academic departments in the ETM field has dramatically risen during the last 30 years. There were only 30 programmes during the 1970s; however, to date there are over 160 educational institutions offering degree programmes, and new programmes are being added every year.

2 The process of identifying ETM programmes is not easy because of the variety of titles that academic institutions use; however, the most common degrees are *engineering management*, and *technology management.*

3 Most of the ETM programmes are located in the USA, and about 69% of degrees are offered by engineering schools.

4 Common courses in both engineering and business schools are: strategic planning, accounting, operations research, competitive strategies, creativity management, behavioural science, decision analysis, team building, change management, R&D management, personnel management, technology management and law.

5 The above studies have a number of implications for the proposed PhD in Technology Management programme at UB:

- the field is growing and needs more qualified PhDs to teach, conduct research and work in industry and consulting
- Technology Management is an inter-disciplinary field that requires a balance of Business and Engineering courses and concentrations. UB has designed its PhD programme using the resources and faculty primarily of the Schools of Engineering and Business
- there is a growing need for more focus on technology oriented entrepreneurship and corporate new venture creation.

Table 1 PhD in Technology Management

University	*College/School*	*Degree*
New York University	Polytechnic Institute	PhD in Technology Management
Portland State	College of Engineering and Computer Science	PhD in Technology Management
Rensselaer	Lally School of Management and Technology	PhD in Management and Technology
Stevens	Howe School of Technology Management	PhD in Technology Management
Consortium		PhD in Technology Management
Indiana State University		
Bowling Green State University		
East Carolina University		
University of Central Missouri		
North Carolina A&T State University		

4 Comparison of PhD in TM, MOT and EM

In the USA, the PhD degree in Technology Management is offered by four universities plus a consortium of five universities. The four universities are: Polytechnic Institute of New York University (New York, New York), Portland State University (Portland, Oregon), Rensselaer Polytechnic Institute (Troy, New York), and Stevens Institute of Technology (Hoboken, New Jersey). The consortium is made up of Indiana State University (Terre Haute, Indiana) as the lead institution, Bowling Green State University

(Bowling Green, Ohio), East Carolina University (Greenville, North Carolina), University of Central Missouri (Warrensburg, Missouri), and North Carolina A&T State University (Greensboro, North Carolina). Table 1 shows a summary of these programmes and universities. While the term 'Management of Technology' is widely used for master's programmes, it is not currently used for PhD programmes.

The programmes have much in common, but have notable differences. Many programmes offer specialisations, and universities tend to differentiate themselves through their specialisations. For example, Stevens Institute of Technology offers five areas of research, while NYU Poly does not identify specific areas of emphasis. Rensselaer focuses on business areas, while the Consortium focuses on engineering areas. All programmes require a master's degree with a minimum grade point average. Standardised test scores (such as the Graduate Record Exam) are required, and proven English competency (including the Test of English as a Foreign Language) may be required of international students. The number of required credit hours varies from school to school, ranging from 45 to 75 credit hours beyond the master's degree.

New York University – Polytechnic Institute

The programme at NYU-Poly is offered in the Department of Technology Management, and is made up of courses in management, technology management, research methods, and associated doctoral seminars. No areas of emphasis are identified. A total of 75 semester credit hours are required beyond the master's degree, including 51 credits of course work and 24 credits of research.

Portland State

The PhD degree is offered by the Department of Engineering and Technology Management, part of the College of Engineering. A wide range of specialisation areas is available. Portland State operates on a quarterly system, where three quarters are equal to two semesters. At least 99 quarter credit hours of work are required beyond the master's degree, including 60 quarter hours of classes (divided into core, specialisation, and methods). Many of the available specialisation courses are from other departments, including business administration and social sciences. In addition, 12 quarter hours of independent study are required, leading to a paper that is suitable for a technical conference. At least 27 quarter hours of dissertation research is also required. A student is expected to create at least one paper that could be published as a technical journal article. A previous degree in engineering or related discipline is required.

Rensselaer Polytechnic Institute

The PhD in Technology and Management is offered by the Lally School of Management and Technology as their only doctoral programme. The degree is offered in two areas:

- finance and accounting
- strategic management

The degree requires 90 semester credit hours after the Bachelor's degree, and up to 45 of these can be derived from a Master's or MBA degree. Admission is limited to eight

students per year. The normal curriculum assumes that a PhD student enters the programme with a master's degree in management.

Stevens Institute of Technology

The PhD in Technology Management is offered by the Howe School of Technology Management. The programme features five research areas:

- technology innovation and entrepreneurship
- decision technologies
- process innovation
- teams and leadership
- project management,

The degree requires 90 semester credit hours, of which up to 30 credit hours may come from a master's degree. The degree requires 15 to 30 credit hours of course work and 30 to 45 credit hours of dissertation research.

The Consortium

The PhD in Technology Management is offered by a consortium of universities, working together to offer distance classes to their students. The programme contains five areas of specialisation:

- construction management
- digital communication
- manufacturing systems
- human resource development & industrial training
- quality systems.

The degree requires a minimum of 66 semester credit hours plus an internship of six credit hours. The course work is made up of a general technology core (15 credits), specialisation (24 credits), and research core (27–33 credits, including dissertation research of 18 credits). Most courses are available on-line, but two brief seminar courses are conducted on the campus of Indiana State University.

Table 2 summarises the admission requirements of each institution.

Linton (2007) made a comparison of universities and research institutes that had two or more academics publishing in select technology management related journals. Rensselaer and Stevens were the only schools from Table 1 to be listed in this article. George Washington University, Massachusetts Institute of Technology, and Harvard, which will be identified in other categories, were also identified in the article.

Table 2 Admission requirements

	Statement of purpose	*Letters of reference*	*GPA*	*English proficiency*	*GRE/GMAT*	*Essay/project*	*Industry experience*	*Previous education*
University of Bridgeport	Required	2	3.3+	Required	Required	Required	3+	Please see Figure 1
New York University	Required	3	B+	TOEFL 90+	Required	Required	Preferred	None specified
Portland State	None specified	3	3.0+ UG 3.25+ GR	TOEFL 575+	1100+ sum of verbal and quantitative, or verbal and analytical	Research interests	None specified	Engineering
Rensselaer	None specified	None specified	3.3+	250+	None specified	Resume	None specified	None specified
Stevens	Required	2	None specified	TOEFL (iBT) 79+ Paper-based 550+ IELTS 6.5+	Required	Resume	None specified	None specified
Consortium	Required	5	3.5+	None specified	Required	Resume	3+	MS degree in relevant field

4.1 Engineering management

There are several universities offering a PhD in Engineering Management. These are all offered in engineering schools/colleges, and generally require that applicants have a bachelor's degree in engineering or physical science. While the engineering management degree is similar to the technology management degree, there are differences, and course work and research are more closely related to engineering than in most technology management programmes. Degree requirements include course work and research, and range from a minimum of 42 to 60 credit hours beyond the master's degree. The existing engineering management programmes include:

- George Washington University, PhD in Engineering Management
- Missouri University of Science and Technology, PhD in Engineering Management
- Old Dominion, PhD in Engineering Management
- Portland State University, PhD in Systems Science with a concentration in Engineering Management
- Stevens, PhD in Engineering Management
- University of Alabama in Huntsville, PhD in Engineering, with a concentration in Engineering Management
- University of Tennessee Space Institute, PhD in Industrial Engineering, with a concentration in Engineering Management
- Southern Methodist University, D.E. with a major in Engineering Management.

4.2 Other related programmes

Entrepreneurship is also offered as a PhD. These degrees are all offered in Schools of Business. The existing Entrepreneurship programmes include:

- University of Louisville, PhD in Entrepreneurship
- Oklahoma State University, PhD in Entrepreneurship
- University of North Carolina, PhD in Business Administration, with a concentration in Strategy and Entrepreneurship
- Carnegie Mellon, PhD in Technological Change and Entrepreneurship
- University of Washington, PhD in Technology Entrepreneurship
- University of Missouri – Kansas City, PhD in Entrepreneurship and Innovation
- Massachusetts Institute of Technology, PhD in Management with a concentration in Behavioral and Policy Sciences, and a secondary concentration in Technological Innovation, Entrepreneurship & Strategic Management
- Syracuse University, PhD in Entrepreneurship.

There are several other related PhD programmes that have similarities to Technology Management programmes, as follows:

- Harvard University, PhD in Science, Technology and Management
- Eastern Michigan University, PhD in Technology
- Stanford University, PhD in Management Science and Engineering
- University of California – Los Angeles, PhD in Decisions, Operations and Technology Management
- Massachusetts Institute of Technology, PhD in Technology, Management and Policy.

These are the programmes that were used as input to the design of the programme at UB.

5 Design of the programme

5.1 PhD process and outline

The success and growth of the PhD in Computer Science and Engineering programme licensed in 2005, coupled with the industry need from companies that hire MS in TM graduates were two major factors leading to the PhD in TM proposal. As with most universities, we formed a committee of faculty members and department heads representing the Schools of Engineering and Business to facilitate the development of a programme that would leverage the offerings of both schools. We identified courses in both Schools that were in areas that we could support as specialisations. These areas were based largely on faculty expertise.

We reviewed the structure of PhD programmes in Technology Management, Engineering Management and Entrepreneurship in select universities. Given our objectives and focus, we developed the proposed PhD degree strawman (see Figure 1) as a summary and circulated it to UB's Industry Advisory Board, select universities and students enrolled in our masters programme. Based on the feedback from these groups, we developed the PhD proposal, received the appropriate internal approvals, and submitted it for external review and approval. The external review process is currently underway.

5.2 Structure of the programme and PhD student requirements

The PhD-TM programme is specifically designed to develop interdisciplinary skills and competencies in research, teaching, and management of technology-based businesses. While the PhD-TM is housed in the School of Engineering, the degree encourages interdisciplinary studies across the Schools of Engineering and Business and uses their complementary facilities and faculty.

A PhD student must take courses from Area 1 (New Venture Creation) and Area 2 (Current and Emerging Technologies). Figure 1 illustrates a schematic of the 'PhD TM programme structure'. Table 3 shows the requirements that PhD students must satisfy. If a student wants to focus on Area 1 – New Technology Venture Creation – the student must take three courses from Area 1 and two courses from Area 2. If a student wants to focus on Area 2 – Select Current and Emerging Technologies – the student must take four courses from one of the Area 2 technology specialisations and one course from

Area 1. If the student wants a balance of both areas, the student must select two courses from Area 1 and three courses from Area 2 (from one of the specialisations). As the programme grows, we plan on adding additional technical disciplines assuming that sufficient enrolment justifies adding these disciplines and faculty.

Table 3 Requirements of the PhD in Technology Management

- Total credits required for PhD = 42
- Degree admissions requirements:
  1. Undergraduate Engineering or Technology Degree (STEM** category) and an MBA or MS in Technology Management, Engineering Management equivalent, and three + years of industry experience desired. If a candidate has both Undergraduate and Master's degrees in Engineering or a STEM category, he or she must have at least three to five years of industry experience
  2. Undergraduate Business or Management or TM Degree and a Master's Degree in Engineering, Computer Science or other Technology or equivalent (STEM**) & three + years of industry experience desired
  3. GPA of at least 3.3
  4. Two (2) letters of reference
  5. Personal statement from PhD candidate (background, experience, motivation in pursuing PhD, long term goals, areas or topics of potential research)
  6. PhD candidate must prove English proficiency
  7. GRE exam is recommended
- A one semester teaching practice requirement
- Publication of at least one Journal paper or two refereed conference papers, within the course of the PhD research topic. These publications are not required to be single authored by the student and they may be co-authored with members of the dissertation committee.
- Career preparation alternatives: academic/research, consulting, and/or engineering, technology or management, or technology entrepreneurship
- Students can choose to focus on three study options:
  1. Focus on Area 1: three courses from Area 1 and 2 courses from Area 2 (both from one technology concentration)
  2. Focus on Area 2: once course from Area 1 and 4 courses from Area 2 (from one technology concentration)
  3. Combination of Areas 1 and 2: two courses from Area 1 and three courses from Area 2 (from one technology concentration)

Note: **STEM = science, technology, engineering and math

5.3 Selection of students and admissions criteria

Since the PhD programme is for both part-time and full-time students and is expected to attract both domestic and international students with various backgrounds, we established the admissions criteria shown in Table 3.

5.4 Timeline and major milestones

The PhD degree should be completed in five years for full-time students and seven years for part-time students. A summary of steps, not necessarily ordered, through which a student will proceed, is as follows:

- Admission to the PhD programme of Technology Management on a 'provisional status', if needed
- Completing prerequisites, if needed;
- Restoring the status to 'regular PhD student', if needed;
- Completing the course work requirement for the PhD
- Passing the written comprehensive examination
- Admission to 'Candidacy'
- Selection of a dissertation advisor
- Writing a dissertation proposal
- Oral portion of the comprehensive examination (e.g. dissertation proposal defense), and working on the proposed research topic
- Formation of the dissertation committee (consisting of schools of engineering and business faculty plus an external representative)
- Approval of the dissertation by the dissertation committee
- Successful completion of the dissertation defence
- Submission of dissertation to the School of Engineering
- Graduation with a PhD degree in Technology Management.

5.5 Outcomes assessment

There are two types of outcomes that need to be monitored: Institutional Outcomes and Student Outcomes. The institutional outcomes include

a increase in instruction quality and support. PhD students will be involved in teaching master's level courses

b increase in research funding opportunities. The presence of PhD students will increase the amount of research, and improve the opportunities for outside funding.

c increase in student enrolment. A successful PhD programme would have a noticeable increase in full-time and part-time enrolment. There is significant interest among our current master's students, and strong interest in the area business community for part time opportunities.

The following student outcomes will be strongly emphasised in the programme. The graduate will:

1 be familiar with principles of new venture creation, entrepreneurship, corporate venturing, innovation, and related issues including management, finance, legal issues, new product development, and product commercialisation

2 be familiar with advanced concepts of methodologies in technology management

3 possess a strong background in one or more engineering and technology area offered in the PhD programme

4 possess a strong background in implementing new technology based businesses and ventures

5 be able to critically analyze problems and evaluate the benefits of alternative solutions in new technology-based international opportunities and corporate ventures

6 be able to work in a development team to address specific issues and problems

7 be able to interact and communicate both verbally and in writing with people whose expertise is in different domains and who are located across the globe

8 be able to effectively teach in a higher education institution

9 be able to write quality research papers for inclusion in prominent journals, and research proposals for submission to funding agencies

10 be prepared to become a future leader, professional, academic and researcher with interdisciplinary skills, to join the faculty of leading academic institutions or take high level research, consulting and management positions in industry, non-profit organisations, government or start their own ventures.

6 Major challenges

When we initially reviewed the PhD programmes at other universities, the PhD development team applied many years of experience to the task. We asked some difficult questions such as, 'Who would we hire today as a future leader in business or engineering or technology or a balance of all for our company?' 'What skills, competencies and attitudes would we look for?' 'What mix of soft skills (people, leadership, and team) would we expect?' 'What about ethics, integrity, communications, diversity and a better understanding and acceptance of global diversity, cultures and being able to tap virtual global brains located anywhere and anytime?' 'What about acceptance of and the proactive sponsorship of innovation, entrepreneurship, intrapreneurship and managing change?' 'What STEM areas should we concentrate on?'

In designing the PhD programme we always kept these questions in sight. In general, we also established the following wish list for the potential graduates of the PhD-TM programme to be able to accomplish, once they were in the workforce:

- conduct research and develop strategies and plans to identify, develop and implement innovative technological based solutions
- develop competent interdisciplinary academics and researchers to advance the field of Technology Management

- manage the effective planning and execution of those technology based initiatives and the integration of their impact into the mainstream of an enterprises' strategy, processes and operations
- the application of technology to create wealth and economic development as in successful entrepreneurship and/or intrapreneurship or corporate venturing initiatives
- develop future leader and managers in technology or technology dependent organisations
- develop, lead and motivate high-performance and diversified global teams
- champion and sustain innovation initiatives and environments.

As in most PhD programmes, there will need to be a very high level of interaction between the candidates and the faculty. Additional faculty will be hired; these will need to hold a PhD degree in order to support the programme.

7 Lessons learned

As with any new initiative that is interdisciplinary and crosses individual school boundaries within a university, we have learned a number of valuable lessons in order to achieve success in developing a proposed PhD programme.

A champion from high in the organisation is needed to sponsor the initiative. As in many large initiatives, some team members become focused on the minutia, spending time identifying how their favourite ideas might be included. A champion is needed to tenaciously focus on delivering a workable plan, or it will never be accomplished. Obtaining information, viewpoints, and commitments from all stakeholders is important, but not every idea can be included.

Obtaining the approval of the various schools that have an interest, as well as the approval of the provost, president, and board of directors is more time consuming than expected. Each level of the organisation has a unique perspective and a different set of questions. Significant time must be allocated for approval at every step of the process.

Obtaining support letters from industry and potential students proved to be an excellent method for demonstrating support from the local business community and future recruits. These letters helped prove that a real interest in the programme existed, and that we had multiple sources of potential PhD students. The industry letters also demonstrated that we had the support of potential sources of future research funding.

Various stakeholders had a variety of new ideas, and we needed to actively listen and be open to new ideas. Discussions needed to be open and candid. We also needed to find ways to say 'no' without offending others.

8 Conclusions

- TM PhD programmes are diverse; there is a wide variety of programmes in terms of focus areas, breadth of offerings, types of schools, and the size of programmes.

- Market pull exists. There is widespread interest in the PhD programme within the local business community, recent alumni of the MS programme, and current graduate students.
- Engineering Management programmes are taught in engineering schools, with an expectation that incoming students have a degree in engineering or physical science. Entrepreneurship programmes are taught in business schools, with an expectation that incoming students have a degree in business. Technology Management programmes are more mixed, with students having more varied backgrounds. We prefer incoming students to have both technical and business backgrounds.
- The structure of our proposed programme is based on each student taking a mixture of business and technical courses, which appears to be unique among existing programmes. However, we include the research depth in a single area which leads to a successful research dissertation.
- The approval process has required twice as much time as creating the proposal. Only minor changes have been required during approval, but the time involved was far greater than expected.

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