

Teaching high-tech entrepreneurship: Does it differ from teaching entrepreneurship? (And does it matter?)

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Abstract

A comparison is made of curricula and teaching of entrepreneurship in business and engineering schools. Based on this comparison, as well as an analysis of the entrepreneurship education literature, two primary recommendations are made: 1) for a process-based approach to teaching entrepreneurship; and 2) for greater emphasis on the early stages of the process, especially the value creation associated with the development of the entrepreneurial opportunity. A number of other issues are raised.

Introduction and Objectives

The growth of entrepreneurship, and the teaching of entrepreneurship, has been well documented (see for example references 1-5). The teaching of entrepreneurship was initiated within business schools, and business schools continue to cater to the largest number of entrepreneurship students. The phenomenon of teaching entrepreneurship courses within engineering schools is more recent, and is in a more formative stage of development than programs in business schools.

This paper discusses some differences between the current teaching of entrepreneurship in engineering versus business schools, and also adds the dimension of “high technology entrepreneurship.” The work has been motivated by a strong desire to provide the optimum education content to our own entrepreneurial students at NCSU, in both the Colleges of Engineering and of Management. The ultimate objective is to ensure that we are providing an educational experience supportive of student career aspirations and perceived employer needs.

The outline of the paper is as follows. Firstly, we provide some background comments that provide context and definitions for the categories of entrepreneurship that we discuss in the paper. Next, we compare entrepreneurship curricula as found in engineering schools with those of business schools. We point out some broad but important differences. Thereafter, we provide a selected analysis of the entrepreneurship literature, particularly pointing out issues that complicate

our teaching of entrepreneurship. Finally, we draw together the curriculum discussion, literature analysis, and also our own teaching experiences, in order to propose (for discussion) some recommendations for the teaching of entrepreneurship.

Background Comments regarding “Entrepreneurship,” “Engineering Entrepreneurship” and “High-Tech Entrepreneurship”

Over the past 10 years there has been a dramatic growth in the number of programs and course offerings in the field of entrepreneurship. This has been accompanied by an increasing acceptance of, and an increase in status for, the field. The largest activity has been in the management and business schools, and the increase in activity is attested by the increase in the number of faculty positions dedicated to teaching and research in the field². Courses and specializations are offered at both undergraduate and graduate levels in these schools.

Within engineering schools there has been a similar increase in the interest in entrepreneurship, so much so that the term “engineering entrepreneurship” has been associated with this phenomenon. There are some important differences between offerings at the two types of school. In engineering, most of the course offerings are aimed at undergraduate students, and faculty interested in, but not formally trained in, entrepreneurship, management, or business are initiating the offerings. In both schools, the teaching is strongly supported by part-time educators, such as “executives-in-residence,” outside business executives or experienced entrepreneurs. The offerings in engineering schools all have a strong technology component or association.

The term “high technology entrepreneurship” is **not** in general use. In our program at NCSU, we use it as a term of convenience, to describe that activity of entrepreneurship that uses technology as the primary basis to achieve competitive business advantage, and in particular technology-based new venture creation with large market opportunity and high growth potential. We will use it in this sense within this paper.

We will now make some general comparisons of the different entrepreneurship curricula within business and engineering schools.

Entrepreneurship Curricula

Entrepreneurship programs and courses offered at both engineering and business schools were examined through web descriptions, prescribed texts, and discussions with faculty. A high level, generalized view of these offerings is shown in Figure 1.

Entrepreneurship Curricula in Business Schools

Figure 2 shows a view of topics typically taught at business schools. It is interesting to note that the **core** undergraduate offerings generally map the same topics as the core graduate offerings in the business schools. Most schools offer one or two core entrepreneurship courses, then allow selection from a wider array of topics for the elective courses within an entrepreneurship major. We have found that the text “New Venture Creation” by Timmons of Babson College⁶ is representative of a number of the core entrepreneurship courses – it is also the most commonly

utilized entrepreneurship text in the business schools. Texts utilized by engineering entrepreneurship programs are considerably more varied²⁴⁻²⁶.

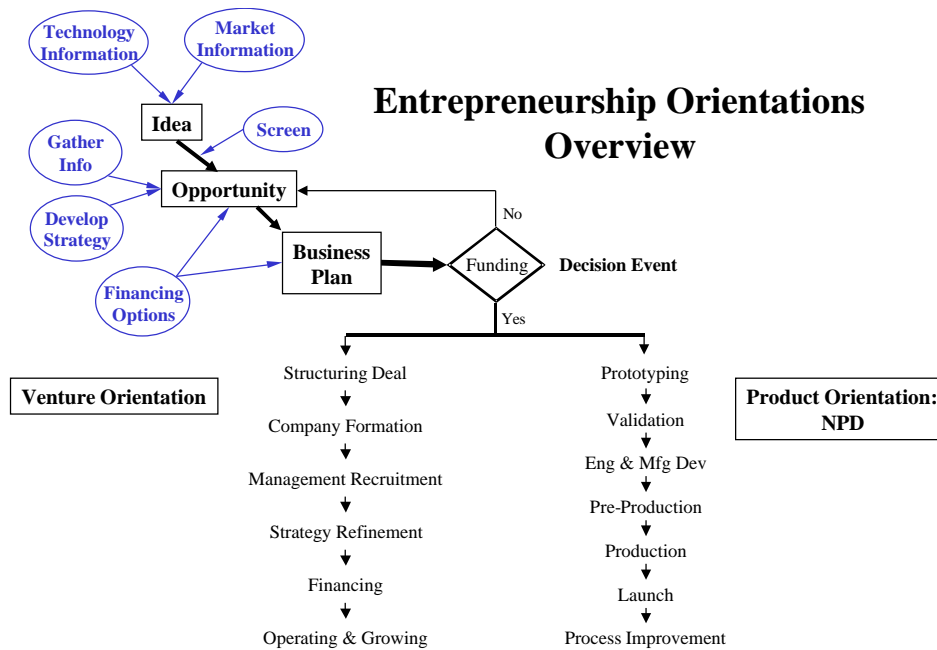


Figure 1 - Entrepreneurship Orientations Overview

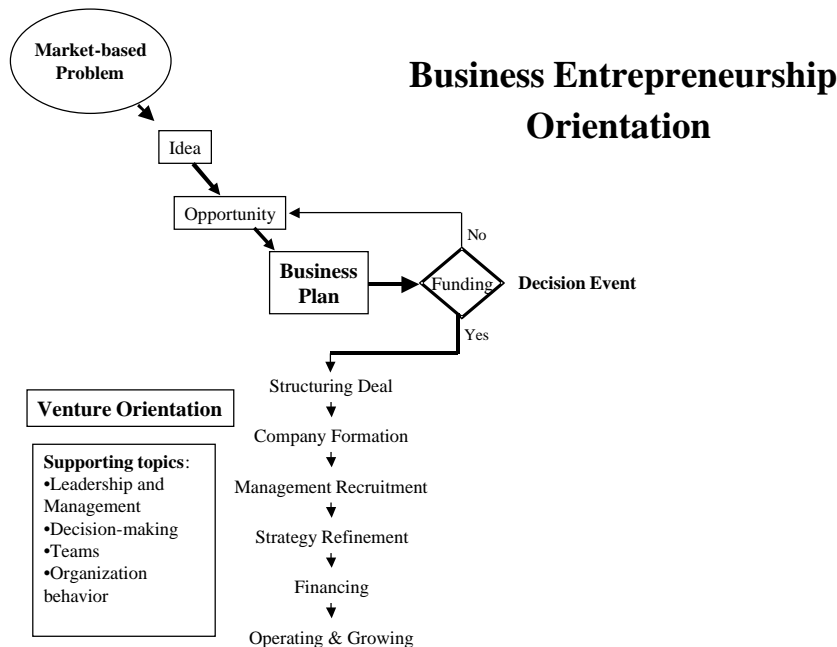


Figure 2 -Business Entrepreneurship

Engineering Entrepreneurship Orientation

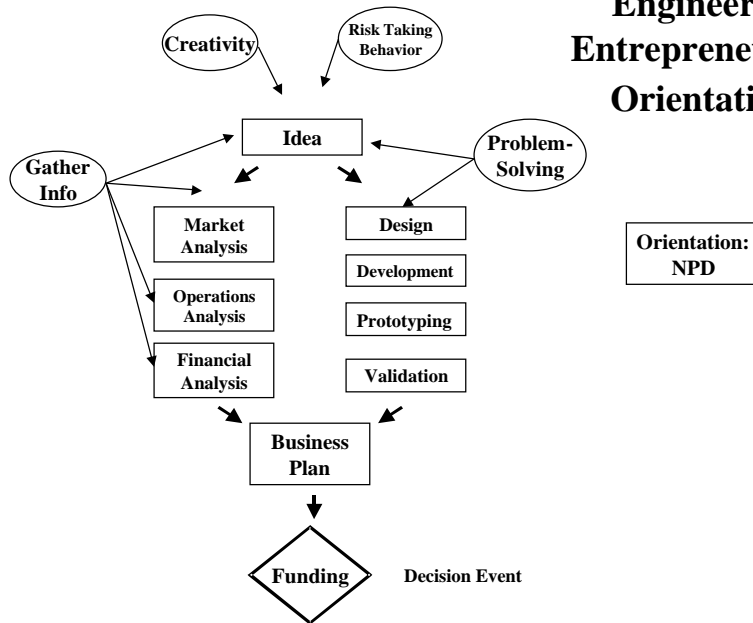


Figure 3 - Engineering Entrepreneurship

TEC's Entrepreneurship Orientation

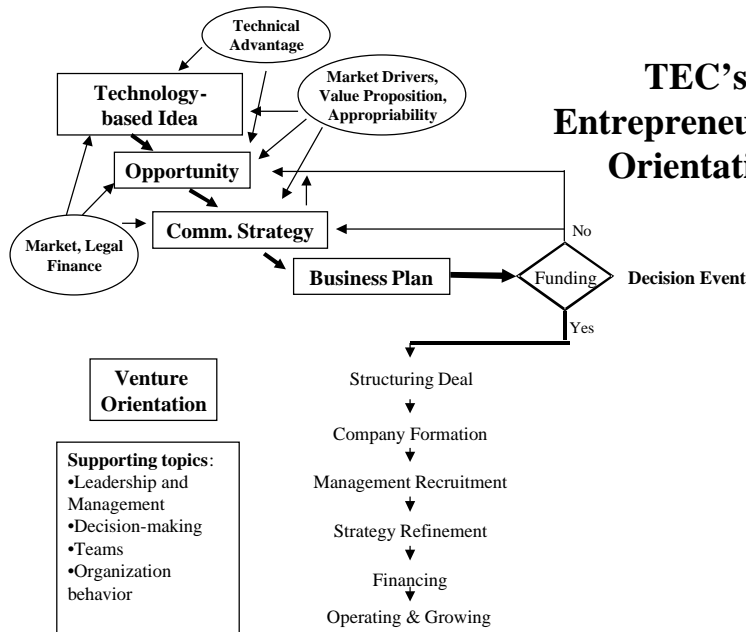


Figure 4 - TEC's Entrepreneurship Orientation

It is important to note that the course offerings typically mention the prospective career paths of candidate students. The following is a typical description⁷: “students who wish to go into business for themselves; students seeking to join an entrepreneurial venture; students who wish to get into the venture capital field; and students likely to become involved in technology management in a large corporation.” These variants are typically reflected within the elective offerings. The elective offerings, and in fact the entire flavor of the entrepreneurship program in a school, can also be influenced by the culture within the business school. For example, in some schools, entrepreneurship is strongly linked to the field of strategy, with a resultant strong emphasis on ‘intrapreneurship.’

A further point to note with respect to the teaching of entrepreneurship within business schools, is the ease with which ancillary topics/skills can be included. For example, behavioral and organizational topics are readily included, both because there is room in the curriculum for these specialty topics, and also because the expertise exists within the business faculty. Typical course offerings (or even sub-course offerings) include: Personal, and Managerial Time Management; Project Management; Negotiations; Decision-making; Management of Technology; Innovation Management; Innovation and Change in Organizations; Venture Capital and Private Equity; New Venture Finance; Corporate Architecture; Building and Leading High-Tech Organizations; etc.

Some business schools also include the area of “New Product and Process Development” (NPD or NPPD) in their curriculum offerings (see Figure 1). In some cases, these courses are linked to departments such as Design, Industrial Engineering, or Operations Management. This gives a strong product orientation to the courses, and also provides a business-engineering link. Students typically do not generate business proposals within these courses.

Entrepreneurship Curricula in Engineering Schools

Consider now the undergraduate entrepreneurship offerings of engineering schools, that we classify as engineering entrepreneurship, in contrast with the above business school offerings. The typical domain of these offerings is shown in Figure 3. There is a clear technology and product orientation. The rationale for these courses is not readily available, but an oft-quoted justification is the need to create awareness among engineering students of entrepreneurial opportunities, and the business dimension of product development. These courses typically include the development of a business proposal. However, the entrepreneurial course content is typically topic-based, and is often based upon seminars taught by non-faculty members. As the field matures, a more comprehensive approach to the content can be discerned. The activities are almost always team-based. Table 1 represents a summary of topics which are perceived to be important in engineering entrepreneurship offerings, as articulated by a group of engineering faculty engaged in this teaching⁸. These topics are clearly considerably sparser than those that would be covered in a graduate entrepreneurship concentration at a business school.

Table 1: Entrepreneurial skills, organization and issues identified by Engineering⁸.

Foundational Skills	Cross Disciplinary Skills	Team Organization	Broad Issues
Business models	Communication	Cross functional teams	Entrepreneurial thinking
Fundamentals of financial	Negotiation	Valuation of team skills	Nurture entrepreneurs
Negotiation	Project management	Small teams	Mix teams
Intellectual property/legal	Organizational behavior	Long-lived teams	Value other members
Marketing			Decision-making
Opportunity recognition			Survey results

It may be worth considering two engineering entrepreneurship programs in greater detail. At NCSU, there is an entrepreneurial option for the Senior Design course in Electrical and Computer Engineering⁹. Teams of students undertake the development of a technology-based product, usually including prototype development. However, the teams are structured as ‘companies,’ and a number of business aspects are included, for example, market opportunity, market research, the purchase proposition, etc. The seniors in the ‘company’ are supported by underclassmen that can join the company (for limited credit), and undertake support activities, including market and other research. There are weekly topical seminars to provide supportive knowledge and skills. These are presented primarily by outside entrepreneurs. The course has been evaluated highly by students, and the initiating faculty has undertaken an impact study¹⁰. The primary objective of the course is to create awareness and some enthusiasm for entrepreneurial activities, rather than a comprehensive knowledge and skills base for new venture creation. Further objectives are to develop team and leadership skills. The course sequence has a positive impact on student confidence and graduation rates, and is a positive inducement to bring students into the department¹⁰. A few projects have resulted in start-up ventures. A big advantage of this type of course is that as a Senior Design variant, it is readily accommodated within an existing curriculum.

A recently developed course sequence at the Pennsylvania State University deserves mention¹¹, as it represents an example of an engineering entrepreneurship program with strong business school links. The engineering entrepreneurship minor consists of six classes in total: four requirements and two electives. Members of both the colleges of engineering and business helped develop the minor and co-teach several of the required courses. The first two required classes are entrepreneurial leadership and entrepreneurial business basics. The leadership class focuses on both leadership and interpersonal skills, and the second class teaches the basics of finance, marketing and intellectual property. The third class normally taken is called the Technical Entrepreneur and expands to include more classic entrepreneurial behaviors such as risk-taking, problem solving and creativity, while beginning to add the basic underpinnings of a business framework, and continuing to develop student’s team-building skills. The objectives of the capstone class, Entrepreneurship and New Product Development, are consistent with new product

*“Proceedings of the 2002 American Society for Engineering Education Annual Conference & Exposition
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development processes and emphasize prototype development and market needs assessments in a team environment involving new product categories and extensions. At the end of the class, students present a prototype and business assessment to corporate intrapreneurs and venture seed fund representatives. Students are required to take two electives from a wide range of related course offerings including business law, marketing, finance, statistics, management, and logistics. The course is representative of a positive trend that we believe to be occurring in engineering entrepreneurship programs, namely, collaboration with business faculty to more comprehensively teach the foundational business and entrepreneurial skills to undergraduate engineering and science students.

A further positive aspect of the entrepreneurial activities within engineering schools has been the willingness to experiment. A rich array of innovative programs has been developed over the past few years, with little apparent constraint imposed by academic conservatism¹².

An observation regarding existing engineering entrepreneurship programs is that there does not appear to be a strong differentiation between ‘income replacement’ and ‘wealth creation’ ventures, i.e. between technology based ventures with low and high growth potential, respectively. This is understandable for undergraduate programs, where the technology potential is relatively limited. An implication is that it is not easy to identify entrepreneurship programs and curricula that clearly meet our definition of ‘high tech entrepreneurship’, i.e. with a high technology, high growth, venture-funded orientation. This is discussed in the following subsection.

High Technology Entrepreneurship Curricula

As pointed out above, it is difficult to identify curricula that are oriented specifically to high tech entrepreneurship. From a university perspective, there is clear interest in high tech entrepreneurship, as the high growth criterion implies that there is potential for universities to gain from the new venture activities, from royalty or equity positions. (In reality, the low growth, income replacement new ventures that utilize university intellectual property do not justify the original investment in patent protection). As teachers, an emphasis on high growth opportunities should also ultimately have the largest economic impact (if we can teach students to be successful!). But there is a clear difficulty, in that there needs to be significant and available technical assets, as well as the available technical expertise to develop the product idea and entrepreneurial opportunity. This is difficult to accomplish at the undergraduate level, and in general our observation is that the number of student projects at the undergraduate level which fall into the high-tech, high growth category likely to be venture funded are in fact small.

There are two possible solutions to this dilemma. The first is to use a case-based approach, rather than real projects. This approach is commonly undertaken at business schools. The negative aspect of this approach is that it does not allow students to be fully engaged in the early stages of value creation, i.e. in the complex process of teasing out the product ideas and entrepreneurial opportunities from the technological opportunity, as the technical expertise is not present in the student teams. (This issue is discussed again, later in the paper). A second approach is to undertake real, high tech projects, but limit the teaching to interdisciplinary teams that contain the appropriate level of both technical and business expertise. This allows one to have, under the appropriate circumstances, the rich combination of a technology with unique capabilities and well-

researched market opportunities, that are the necessary ingredients of a high-tech, venture-funded opportunity.

High-tech entrepreneurship is therefore primarily taught at the graduate level. One example of a curriculum with a high tech entrepreneurial focus is our graduate technology commercialization sequence at the North Carolina State University. To address the above problems, we have adopted the following strategies: we ensure a technology-rich environment by accessing technology portfolios inside and outside the university; we include graduate students from science and engineering to ensure the necessary technical capabilities within the student teams; we include business students with market knowledge and/or market access; we emphasize the development of (market) information gathering skills; and we utilize an idea generation process which develops and evaluates technology-product-market linkages¹³. The curriculum overview is shown in Figure 4. At this level it is similar to the new venture orientation of a typical business school curriculum (Figure 2), but with a far greater emphasis placed on the value creation associated with the idea and opportunity development. We have benchmarked this program against other graduate entrepreneurship programs in the USA, and there are unique features, which have been described previously¹³.

Relevant Curriculum Issues raised by the Entrepreneurship Literature

Having presented an overview of curricula, it is worth examining the entrepreneurship literature, especially the entrepreneurship education and training literature, in order to gain further insight into the problems of teaching entrepreneurship. There is a wealth of information, and the discussion is therefore necessarily cursory. The following represent some of the ensuing issues:

- The ‘why’ and ‘what’ of teaching entrepreneurship (or ‘what is the extent of the field of entrepreneurship, which should define what we should teach?’) We can illustrate this as a problem by simply considering the definitions of entrepreneur and entrepreneurship. Despite nearly two centuries of the use of the word entrepreneur (it is ascribed to Richard de Cantillon, with an emphasis on ‘risk-taking’), there remains discussion about the extent of the field of entrepreneurship¹⁴. There is general agreement that the definitions should be broad, i.e. encompassing a broad definition of entrepreneurial opportunity, and identifying a broad range of entrepreneurial skills. Two major emphases can be discerned – behavioral and economic. A behavioral view defines entrepreneurship ‘as the pursuit of opportunity beyond the tangible resources currently controlled,’ (after Stevenson and Gumpert¹⁵) This broad definition then allows inclusion of topics such as ‘social entrepreneurship,’ i.e. entrepreneurship within the context of social and bureaucratic change. More common definitions of entrepreneurship have economics or business as a primary focus (traceable to Schumpeter, 1934¹⁶). Some definitions are limited to new venture creation¹⁷, while some extend beyond new venture creation to include exploitation of new opportunities within the context of existing businesses, as in the Schumpeterian view. It is quite clear, however, that the topic **does** include the skills and personal characteristics of entrepreneurs^{18,19}. It is worth noting that, despite awareness of the broadness of the field of entrepreneurship, in practice a narrower stance is commonly adopted. The implication of the variety of views of the field of entrepreneurship is that the same broad range is reflected in the curriculum contents, teaching objectives, and teaching approaches.

- The ‘how’ of teaching entrepreneurship (or ‘what pedagogical approach should we use to teach entrepreneurship?’) Consistent with the previous comment, there is an acknowledged lack of a conceptual or theoretical framework for the study of entrepreneurship (Shane and Venkataraman, 2000, and subsequent responses to that paper¹⁴). Fiet has argued for a ‘theory-based’ approach to the teaching of entrepreneurship²⁰, but the examples he has given represent components of theory borrowed from related fields, rather than an encompassing theory of entrepreneurship, or entrepreneurial behavior. Bechard and Toulouse²¹ have attempted to validate a didactic model for entrepreneurship training, but the specific teaching objectives, derived from the subject matter of research publications, appear to be incomplete. The lack of a conceptual framework has resulted in experience-based teaching of entrepreneurship. This is particularly true in engineering entrepreneurship, where there is a reduced ability (or at least reduced tendency) to draw theory components from related fields. Experience-based teaching has clear limitations. (Would we consider teaching physics, chemistry or civil engineering on the basis of personal experience?). The need to teach entrepreneurship using an experience-based approach also leads naturally to the use of outside entrepreneurs as the primary source of teaching content.
- In addition to the lack of a conceptual framework for entrepreneurship, the research into the field of entrepreneurship remains relatively immature. The implication for us as teachers is that there remains a lack of clear predictors of important outcomes (e.g. predictors of success for high tech entrepreneurial ventures; authoritative descriptions of entrepreneurial competencies, etc). This clearly makes it more difficult to identify important factors for success, and therefore teach students to become successful entrepreneurs.
- The ‘how well?’ of teaching entrepreneurship. There is relatively little published information regarding the efficacy of entrepreneurial programs or courses, particularly in the newer programs within engineering.

Note that these difficulties apply to the teaching of entrepreneurship in both business and engineering schools.

Advocating Changes in the Teaching of Entrepreneurship

Having discussed curriculum differences, in addition to providing a brief taxonomy of current difficulties in the teaching of entrepreneurship, we wish to advocate some approaches for improvement, which partly address the above issues.

A preferred teaching approach of many disciplines is that of theory taught in conjunction with applications that allow students the necessary practice. In the absence of theory and a conceptual framework, is there any alternative to experience-based teaching? In our opinion, the alternative is ‘**process-based**’ teaching. A process is more amenable to generalization, and is therefore pedagogically preferred over experience-based teaching. As described in a previous paper¹³, the process we have developed broadly encompasses the set of entrepreneurial activities, and allows supportive educational topics (teams, decision-making, information-gathering techniques, etc) to be included. It is a two- or three-semester process that provides the framework for the entire curriculum. It represents a generalized mapping of the entire entrepreneurial process, based upon more than a mere cataloguing of experiences, and includes a development of the cognitive activities of entrepreneurship¹³. Students utilize real projects, and the process has had a

demonstrated impact on student performance and the creation of new ventures. We have argued that it develops the necessary knowledge and skills for an entrepreneur in both new venture and corporate environments. In addition, it may be argued that it supports a team-based entrepreneurial orientation, rather than being reliant upon the entrepreneurial orientation of the individuals.

The second major issue that we wish to raise is our perception that there is too little teaching emphasis on the early, conceptual stages of the value creation process. To expand on this point, it is noted that all entrepreneurship teaching includes the concepts of an 'idea' and/or an 'opportunity.' In general, teaching of entrepreneurship (in the context of new ventures) in the business schools follows the following path:

Market opportunity and customer need → product idea → entrepreneurial opportunity → proposal

In contrast, in the engineering schools, the teaching path tends to be the following:

Technology → product idea → entrepreneurial opportunity → proposal

The situation in which the idea originates from the market side is typical of teaching in the business school environment, and this is necessitated by a general lack of access to viable technologies (although a number of business schools are attempting to address this problem). The approach is consistent with many real entrepreneurial activities, particularly those that represent evolutionary product development, or a market extension strategy. It is, however, not consistent with the important cases of disruptive technologies, radical new products, and entirely new markets. This necessitates a case-based teaching approach. In the case of the technology-originated product idea, common in the engineering entrepreneurship teaching arena, the technology capabilities available to the undergraduate teams are generally limited. Only in very few cases do they provide a broad platform for radical new products, and qualify as disruptive technologies with large market opportunities. More commonly, new ventures which result fall into the category of 'income replacement.'

We would like to continue to emphasize the importance of the early stages of the process by a discussion of 'entrepreneurial opportunity,' a concept which is central to entrepreneurship. There has been some discussion in the literature regarding the most appropriate definitions of the term^{14,22}. A commonly utilized definition is that provided by Timmons⁶, which emphasizes the notion of new venture creation. A more inclusive definition is that of Shane and Venkataraman¹⁴, which describes it as "those situations in which new goods, services, raw materials, and organizing methods can be introduced and sold at greater than their cost of production". In this context, we differentiate between ideas (at one extreme these may occur as a 'primordial flash,') and opportunities, which must be **developed** rather than simply identified. We view this as a process, rather than a simple activity, and this process of developing the entrepreneurial opportunity represents the creation of significant value from the technology capability. To emphasize the importance that we place upon this process, we typically spend nearly one semester in teaching and undertaking this opportunity development. In contrast, our examination of entrepreneurship curricula suggests that this is more commonly taught in one class or session. We believe that the under-emphasis on the opportunity, especially in teaching the process of opportunity development, is due in part to what we term the 'decision event bias' imposed by the peculiarities of the venture industry in the USA. The venture capital industry typically has an excess of opportunities made available for funding consideration, of which a very low percentage, typically far less than 1%, are actually funded. The industry has therefore been able to adopt a 'decision event' model, and it does not need to be involved in the early stages of opportunity development. A natural outcome

has been that there is a very large emphasis on the business proposal, and the content of a good business proposal, but little emphasis on processes for developing the opportunity, and thus the proposal.

We believe that it is important to note that the emphasis on the opportunity development that we are advocating is consistent with recent recognition of the importance of the ‘front end of innovation.’ This importance has recently been articulated by a group of researchers representing a large number of innovative industries²³. The implication is that this emphasis represents an important educational component for our entrepreneurially-oriented students who will embark upon careers in a corporate environment.

In summary, we are advocates for a process-based approach to the teaching of entrepreneurship, and for a greater emphasis on the early stages of entrepreneurial opportunity development and value creation.

Conclusions

Entrepreneurship curricular in engineering schools have been compared to curricula in business schools, and some major differences have been pointed out. Difficulties in teaching entrepreneurship include: the fact that the field is still evolving; lack of a theory or conceptual framework for entrepreneurship, which has resulted in a preponderance of experience-based teaching; the relatively small current body of literature which describes entrepreneurial success factors which can be incorporated into a teaching pedagogy; and a lack of data which tests the impact of current teaching methods.

Recommendations that we are advocating include:

- Advancing from predominantly experience-based teaching
- Adopting a process-based teaching approach in the period until a comprehensive theoretical construct for entrepreneurship is developed
- A greater emphasis on the early stages of value creation associated with the opportunity development
- Developing stronger links between the engineering and business schools, on the one hand to improve the teaching of foundational business skills to engineering students, and on the other to provide the necessary technology access and expertise necessary to the business school entrepreneurship to undertaking high tech entrepreneurship programs
- Undertaking far more assessment of teaching efficacy

Acknowledgements:

The authors acknowledge useful discussions with Prof. Tom Miller of Electrical and Computer Engineering, NCSU. Partial support for the TEC Program from the Kenan Institute for Science, Technology and Society is gratefully acknowledged.

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