The Creative Entrepreneurs Organization: Developing Innovative Products and Businesses

by

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Abstract

Global socioeconomic trends are changing the nature of the American workplace. To address the challenges brought about by these changes, American engineering education must focus on developing students into future professionals, equipped to thrive in the fast-paced, technologically intense, globally competitive workplace of the future. One of the most effective ways to prepare students to face the future is by teaching them to innovate.

This thesis presents the "Creative Entrepreneurs Organization: Developing Innovative Products and Businesses" (CEO) concept as a method by which Virginia Tech could help students learn innovation. The CEO concept is a student-involvement program intended to develop students into successful entrepreneurs as they work together in small teams to develop and market intellectual property. This Program is intended to produce revenue for the University by virtue of the successful commercialization of the intellectual properties it generates. Additionally, the CEO Program will allow faculty and students to share in the financial rewards associated with the intellectual properties they generate.

The CEO Program concept is presented in light of current trends in the business and academic worlds. Various issues related to its implementation are addressed. The Program is evaluated for its expected value to students, to the University, to the State, and to the Nation. A survey is presented by which the success of the Program can be measured.

For the CEO concept to be successfully realized, several challenges must be overcome. First, the University must embrace this somewhat unorthodox Program in which both educational *and* financial motives play significant roles. Second, there must be a Program Advocate who will be

able to effectively communicate the value and feasibility of the Program. Third, fiscal and physical resources must be available to ensure the successful start-up and operation of the CEO Program. Finally, the Program must find ways to nurture creativity in its participants.

I conclude that the effort required to implement the CEO Program is outweighed by its potential benefits to students, to the University, to the State of Virginia, and to the Nation. Therefore, I recommend that the Virginia Tech College of Engineering consider the CEO Program for implementation.

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Chapter 1

The Need for a New Educational Approach

1.1 Marketplace Trends and Implications

A variety of global socioeconomic forces are changing the nature of the American workplace. Foremost among the myriad trends that could be mentioned are the globalization of economies, a shift away from reliance on traditional manufacturing, and the downsizing of many industries. As these forces continue to shape the business landscape, American engineering education must continually adapt to ensure that its graduates will thrive in the marketplace of the future.

1.1.1 Globalization

One of the marketplace trends that is currently shaping the world and seems likely to continue to do so, is the trend toward *globalization*. This term, as it is commonly used, refers primarily to the increase in the cross-border movement of information, people, and products. It has also been used to refer to the reduced emphasis on national identity and borders (particularly in view of the increased prominence of supranational economic and political arrangements). For the purposes of the ensuing discussion, the following definition will be used:

> ***Globalization***: *the increase in the cross-border movement of information, people, and products; and, the broadening of perspectives that facilitates consideration of the entire world in one's conception of business resources, needs, and opportunities.*

The globalization of the modern world is the result of various forces: trends toward deregulation by many governments [1, 2],* the advent of an increased number of economically viable nation-states [3], and the technological revolution [4, 5].

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* Numbers in brackets refer to references listed at the end of this thesis.

1.1.1.1 Trend Toward Governmental Deregulation

The trend toward governmental deregulation is a significant driving force in the globalization of economies worldwide. This trend is fueled by the increasingly prevalent assumption that free economies are more productive than economies heavily regulated by governmental mandates, and that "private companies are the real creators of economic wealth [6]." Impetus for deregulation has been provided by a host of supranational organizations and agreements. These include:

- World Trade Organization (WTO);
- General Agreement on Tariffs and Trade (GATT);
- North American Free Trade Agreement (NAFTA);
- European Union (EU);
- Association of Southeast Asian Nations (ASEAN);
- Asia Pacific Economic Cooperation (APEC) group; and
- MERCOSUR (an acronym for "Mercado Comun del Sur," or "Common Market of the South." Member countries include Argentina, Paraguay, Uruguay, and Brazil).

These organizations and agreements seek to promote freer trade internationally or among member nations by reducing tariffs, quotas, regulations limiting foreign direct investment, and the like.

Not only are these supranational agreements significant, but individual nations have been liberalizing many domestic industries. Deregulation throughout Asia includes changes in Japan, South Korea, Malaysia, Singapore, Thailand, and India in telecommunications [7-9], banking [10-12], oil [13], airlines [14], and other industries [9, 15]. In Europe, deregulation is dictated by EU membership criteria [16], as well as by individual governments, from Sweden [17] to Greece [16] to countries formerly under Soviet rule [6]. Africa and Latin America, though fighting a steeper uphill battle, are also joining the deregulation bandwagon in order to entice foreign capital and stimulate their domestic economies [18-21].

This global trend toward deregulation is changing the nature of governmental involvement in the economic realm. Far from heralding the demise of the nation-state [6, 22], deregulation simply implies a change in the nature of the government-industry relationship. Rather than regulating every transaction or investment occurring within and across their borders, "the first move of most governments is to create a macroeconomic climate under which business can operate most effectively [6]." The motivations behind governmental economic involvement will, of course, continue to be the creation of jobs, the increase in exports, the importation of high-tech, high-paying jobs, and general economic improvement [6].

The implications of worldwide governmental deregulation are significant. There will be less stability and increased competition in virtually every high-tech industry. Capital, information, technology, and labor will move across borders with increased ease. Product life cycles will speed up. The world will continue to seem smaller and move faster.

1.1.1.2 Proliferation of Players in the World Market

Another factor that has and will continue to shape the landscape of tomorrow's marketplace is the increase in the number of competitors. The end of colonialism, the collapse of communism, and the rise of Pacific Rim countries are primary factors in the proliferation of viable economies throughout the world.

The end of colonialism during the past several decades and the more recent collapse of the Soviet Union have lead to a proliferation of economically viable nation-states [3, 6, 23]. It seems likely that there will be an increase in competition from a skilled workforce in many of these countries.

During the 80's, the Land of the Rising Sun rose to center stage in American media and business commentary. Japan had risen literally out of the ashes of defeat at the end of World War II to become recognized as an economic superpower [24, 25]. And though Japan has not supplanted the US as *the* superpower of the world (in the full sense of the word), Japan has certainly become an economic force with which to be reckoned.

Meanwhile, as America's collective attention was focused on theories and hype about Japan's surreptitious takeover of America, other Asian-Pacific countries were springing into economic life, seemingly unnoticed. Though they still have a long road ahead of them, many other Asian-Pacific countries have now attracted the attention of the rest of the world. Among these new players are Malaysia, Singapore, South Korea, Taiwan, and China. These countries can no longer be ignored by the rest of the world; they must be considered as economically significant entities, corporately as well as individually.

This proliferation of economies is particularly significant in light of the development of technology, which by its very nature is highly transferable. Nations no longer must rely on sea power or natural resources to ensure their position in the world; technology enables countries everywhere to compete on almost equal footing with their most developed counterparts.

1.1.1.3 Technological Revolution

This century has witnessed a veritable revolution in technology. The arrival of the automobile and air transportation on the American scene increased the pace of life. During the years following the Second World War, the challenges of the Cold War and the Space Age lead to more technological advances. These advances, foremost among which was the development of the computer, soon worked their way into the average American home and place of work. In the ensuing years, the pace of technological advance has only increased.

The technological revolution, as it has been called, is comprised of huge advances in communications and information capabilities, which are both causes *and* effects of the more general technological revolution. These mini-revolutions are having dramatic effects on the way we think about business and the world.

Instantaneous, reliable **communication** has become the norm in virtually every corner of the globe, due to the explosive growth witnessed in both the computer and telecommunications industries. Telephones, fax machines, and email have made rapid communication a reality for most of the industrialized world. Today, elementary school children explore Web pages from around the world, while just one generation ago the very concept of an international computer network would have been inconceivable. Videoconferencing is now gaining a strong foothold in the industrial world, promising large savings over traditional business trips. In actuality, the savings realized tend to be somewhat less than sensational, though still welcome by many companies [26].

Communications is also having the effect of shrinking the apparent size of the world and breaking down many long-standing political and geographic barriers. These days, anyone with a computer, telephone, and fax-modem can work virtually anywhere in the world, regardless of their location.

While the benefits of the communications revolution to the American workforce include increased flexibility and freedom, the disadvantage is the empowering effect this revolution has on potential competitors for jobs. For example, with highly qualified English-speaking, American-educated Ph.D.s earning $250-$400 per month in Eastern Europe and in the former Soviet Union [1], what hope do American professionals have of competing?

Almost inseparable from the revolution in communications has been the revolution in **information**. Following just on the heels of advances in computer hardware and software technologies has come the onslaught of kilo, mega, and now gigabytes worth of information. Anyone who has "surfed the Web" for more than a few minutes can certainly attest to the overwhelming quantity of information available at the click of the mouse. Though the increased availability of information has its benefits, the surfeit of information also poses various problems for workers and managers alike [27]. In fact, it was reported that 50% of the annual capital expenditures for some large corporations are going into investments in information technology [28]. In light of these factors, wise management of information is and will continue to be of paramount importance to the successful business enterprise of the future.

As is the case with advances in communications, the increased availability of information will empower individuals everywhere, connect them to the rest of the world, and thus increase the number of competitors in the world market [29, 4, 3].

One of the most significant aspects of technology is its transferability. Due to this transferability, the increases in flexibility and freedom afforded to the American workforce are the same factors that enhance the competitiveness of individuals and companies everywhere. Certainly, the technological revolution will make the world a more competitive place in which to do business.

The technological revolution has the potential to impact the marketplace of the future in several ways. First, the proliferation of computers and improved communication allow for increased interconnectedness among and between markets, organizations, and individuals [29]. Though the concept of a network of associates and colleagues has been around for decades, in the future, those networks will likely span the globe.

Similarly, by increasing the rate at which information can be communicated, the pace of business will be accelerated. Indeed, this acceleration has already been felt in the rate at which decisions are made, products developed, and timelines laid out. For example, Motorola launched an initiative in 1992 to reduce their product development cycle times by a factor of ten in five years [30]. By 1996, Motorola had come out with a methodology for customer-specific integrated circuit design that reduced design time from 7 months to just 7 days [31]. Though the hectic pace of new product development is characteristic of the computer industry, companies in virtually every industry must bring products to market more rapidly than before [32-36].

As the pace of business increases, one of the inevitable results will be the educational "half-life" effect [37]. This implies that after some amount of time much of one's education will become obsolete. Of course, the length of the half-life will vary depending upon the field under consideration, market conditions, and many other factors. Nevertheless, it is now accepted as fact that much of a person's education will likely become obsolete at some point during their career. It is therefore one of the responsibilities of engineering education to instill in students the skills and desire necessary to make them successful life-long learners.

1.1.2 Shift from Manufactured Products

The trend in American industry away from the manufacture of commodity goods can be seen everyday in the foreign labels on common products made or assembled in countries as close as Mexico and as far away as Korea. A frequently cited trend in American industry is toward providing a service [38-40] or producing conceptual or information-based products [40].

Clearly, America cannot compete in industries that rely heavily on low-cost labor to produce low-value-added products [40]. Nevertheless, it would be foolish to assume that America can, therefore, not compete in manufacturing of any kind. American companies certainly have the potential to compete with the world in providing innovative products tailor-made to the changing needs of their customers. However, this is contingent on the development of a new generation of innovative leaders who identify needs as opportunities and envision and produce creative products to meet those needs in a timely fashion.

1.1.3 Downsizing / Outsourcing

One of the trends that has changed the nature of work in America as much as any other is that of downsizing. The impetus to downsize comes from the realization by many American firms that they are overweight, sluggish, and unresponsive to changing customer needs. In order to remain competitive, therefore, many companies have been in the process of downsizing, restructuring, and reengineering their ranks.

Some would prefer to call this process "rightsizing" and point to its benefits in increasing the profitability of the company. In fact, one model of downsizing published in *Business Horizons* does indicate profitability for the company in the short term (less than 5 years). However, the model also predicts that, "by the 5th year, the increased compensation (for the remaining employees) eats away almost all the benefit [41]." This certainly is reasonable, given the erosive effects of downsizing on employee morale, sense of security, and loyalty to the company [42-44]. And while some companies try to offset these negative effects by increasing the pay offered to employees to keep them loyal and motivated, it is not surprising to hear of surveys indicating that workers today worry more about being laid off than they did several years ago [42]. Unfortunately, downsizing, restructuring, and reengineering do not appear likely to go away; a recent survey by *Employee Benefit News* indicates that "employee benefit professionals expect downsizing and organizational reengineering to remain prominent on their companies' agendas for the next several years. [45]"

In spite of all of the disconcerting evidence against corporate downsizing, there is also a positive side to this trend: downsized companies inevitably begin to look outside the walls of the corporation for products and services once provided internally. This practice, known as outsourcing, can be a boon for enterprising small businesses and entrepreneurs [46], particularly in providing business services [47]. According to a 1988 article in *Nation's Business*, displaced corporate executives are a growing presence among those who start or buy new small businesses each year [48].

Whatever else can be said about it, downsizing will continue to shape the way we think about work. Given the current trends mentioned above, it seems likely that the workplace of the future may be characterized by an atmosphere of expendability (in the company's view of its workers as well as in the workers' view of their company); a lack of security; and, the migration of workers from one company to the next. In light of these factors, it seems imperative for American workers to continually update their skills through life-long education to ensure that they will remain competitive in tomorrow's increasingly fluid workplace.

1.1.4 Implications for Engineering Education

As a result of the trends described above, the pace of business will continue to increase, much of one's original education may quickly become irrelevant, and foreign competition will become more prevalent and more intense.

In light of these changes in the workplace, there are several implications for American engineering education. First of all, education must impart to students a greater awareness of the world. We simply cannot afford to continue to graduate students with no knowledge or appreciation of the multitude of other countries in the world. America cannot compete with businesses and individuals in the global economy without some understanding of who those people are.

Second, as a result of the maturation of the technological age, American students must also be taught information and technology management skills [27, 28]. They must not only become comfortable with the technology available, but must learn to thrive in a world permeated by technology and information; and they must learn how to manage these in ways that increase their competitiveness in the global economy.

Another key component of education must be life-long learning; this is particularly true in engineering and technology-intense majors. Specifically, engineering education must instill in students the desire and ability to initiate their own continual education. Students must face the fact that their engineering education will not carry them through their career all the way to retirement. The world is changing much too rapidly for that. It is the responsibility of the educational system to help students learn why and how to become life-long, active learners.

As a result of the trends toward downsizing and outsourcing, creative small businesses and entrepreneurs will thrive. New engineering graduates should consider employment opportunities at both large *and* small companies; some may even wish to start their own enterprises. In order for both of these options to be equally viable, however, students must be imbued with the skills necessary for success. Imparting those skills is the responsibility of the university.

Assume for the moment that, somehow, overnight, universities were able to meet all of the challenges mentioned above. Imagine that they were now producing students with an adequate knowledge of the world, an ability to manage technology and information, and the motivation and desire to be life-long learners. Imagine also that these students had excellent communications skills and knew how to work in diverse teams to accomplish common goals.

Producing such well-equipped graduates would certainly be a landmark accomplishment for the educational establishment. All of those skills are prerequisites for success. Engineers who cannot communicate, do not understand the world, or cannot operate in the “information age” will certainly not succeed in tomorrow's marketplace. However, to be satisfied with meeting just these prerequisites would be myopic. The missing ingredient is **innovation**.

In order for a company to survive in the increasingly competitive global economy, it must continually innovate. In commodity markets, companies must be innovative in finding newer, cheaper, faster ways to produce their products. This is a particularly urgent need once a product begins being produced overseas, where production costs can be an order of magnitude lower than in America. Even in situations in which the products have not yet become commodities (or are not yet produced overseas), it is critical for companies to consistently provide its customers with better products. Intense, global competition demands constant innovation.

For individuals as well, innovation is essential for success. The marketplace of the future will be increasingly competitive, not only in terms of companies competing for customers, but also in terms of individuals competing for positions in those companies.

In conclusion, there are many challenges facing American higher education. Each of these must be addressed if America is to remain competitive in the marketplace of the future. However, in order to maximize its impact on students, I recommend that engineering education focus on two of the most critical areas mentioned above. I suggest that the most significant contributions American higher education can make in the lives of its students are **to teach them to innovate** and to **help them become active, life-long learners**.

1.2 The State of the Educational Union: Survey of Key Literature

In reviewing literature related to the current state of engineering education, one is likely to find few authors who argue in favor of the status quo. The literature is replete with journal articles, conference proceedings, government reports, and foundation studies about "the need of the hour" for engineering education. A comprehensive review will not be undertaken here. Rather, it is my intent to cut to the heart of the issue by drawing attention primarily to recent studies and reports published by particularly significant governmental, industrial, and academic organizations. These include the following:

- American Society of Mechanical Engineering (ASME)
- American Society of Engineering Education (ASEE)
- National Research Council (NRC)
- National Science Foundation (NSF)

- Accreditation Board for Engineering and Technology, Inc. (ABET)

Though each of these organizations views engineering education from its own unique vantage point, there are many similarities in the observations and recommendations they have made. It is to these similarities that I wish to draw attention. Specifically, these organizations and institutions claim that engineering education should:

- focus on the **development** of students **as future professionals** [49, 50]
- address **real-world problems** through close interaction with industry [49, 50]
- incorporate an awareness of **ethical, societal, environmental, and global aspects** of engineering [50-52]
- encourage students to be **active learners** who participate in defining their educational experience [49-51, 53-55]
- help students develop their **interpersonal skills**, particularly **communications** and **teamwork** [51, 52, 55]
- provide **breadth *and* depth** to education [49-51, 53, 55]
- ensure that students become **life-long learners** [49, 51]
- **assess the outcomes** in terms of gains in student learning [49, 56]

1.2.1 Develop Students as Professionals

Engineering colleges must focus attention on the development of students as future professionals [49, 50]. While engineering students have always gone on to assume leadership positions in industry, academe, and government, the increasing demands placed on engineers today necessitate a redoubling of efforts toward the development of professional engineers.

Along these lines, an insightful paper published in *Change* magazine argues for the necessity of a paradigm shift in our thinking about undergraduate education [57]. Barr and Tagg contest that the prevailing "Instruction Paradigm" should be supplanted by a new "Learning Paradigm." In the Instruction Paradigm, the mission of the university is to instruct students; in the Learning Paradigm, its mission is to produce learning in students. The authors argue that the Instruction Paradigm confuses the means (instruction in the form of lecture-based classes, syllabi, etc.) with the end (student learning as measured by increases in student knowledge and abilities). The subtle irony of the Instruction Paradigm is that faculty who receive high marks for excellent lectures (by virtue of their knowledge of the material, enthusiastic presentation, and incorporation of real-life stories, for example), may not actually be producing any measurable increases in student learning at all. By shifting its focus from instruction to learning, the university becomes free to utilize any means that effectively produce learning in students.

Fortunately, this paradigm shift is reflected in the newest accreditation criteria published by the Accreditation Board for Engineering and Technology, Inc. (ABET). Specifically, *Engineering Criteria 2000* requires that engineering departments demonstrate that their graduates have knowledge and abilities in eleven separate categories [56]. The emphasis on measurable student learning and development incorporated at the heart of the upcoming *Engineering Criteria 2000* is noteworthy. Clearly ABET recognizes the responsibility of engineering programs to focus on the development of engineers as professionals.

1.2.2 Real-World Problems

In order to remain relevant, engineering education must maintain strong industrial ties [49, 50]. Universities have long recognized the educational value of real-world industrial problems. Today, in light of decreases in governmental and military funding, there may be significant financial motivation as well [58]. Industry also benefits from such interaction through the application of cutting-edge university research findings to current industrial issues. The challenge for universities is to engage in cutting-edge, relevant, funded research activities while at the same time remaining committed to producing highly competent, professional engineers.

1.2.3 Ethical, Environmental, Societal and Global Aspects

Much has been written on the need for engineering education to address ethical, societal, environmental, and global issues [50-52]. Engineers have historically been aware of the ethical nature and societal ramifications of their work. More recently, they have also become conscious of the environmental impact and global character of modern-day engineering. At the heart of these realizations is the growing conviction that engineering does not occur in a vacuum. Decisions made by engineers every day do not simply affect the company's bottom line; they both cause and are affected by events in courtrooms, neighborhoods, ecosystems, and countries throughout the world. Therefore, engineering students must learn to engineer in a way that is ethical, socially conscious, environmentally sound, and globally aware.

1.2.4 Active Learning

Active, participatory learning is "the norm in many professional fields [49]" and is intuitively superior to passive learning in most situations. As noted by Confucius, "I hear and I forget; I see and I remember; I do and I learn." Certainly the importance of active learning has received significant treatment in key surveys and studies [49-51, 53-55]. Nevertheless, engineering curricula remain comprised primarily of lecture-based courses. Such courses do little to encourage students to participate in defining their learning experience. Engineering education must "make active learning the predominant engineering student learning mode [50]." Many methods have been proposed for stimulating active learning: the use of reverse engineering to promote independent inquiry, the use of self-paced computer-based learning modules, and exposure to open-ended problems, to name a few [53].

1.2.5 Interpersonal Skills, Communications, and Teamwork

Many engineering education pundits have commented on the need for engineers to work well with people [51, 52, 55]. Not only must engineers be technically competent, they must be able to communicate and relate well with a diversity of people. These people, whether customers or coworkers, may not be conversant in technological vocabulary and concepts. Furthermore, they may not share the engineers' goals or values. This means that engineering students must be given ample opportunity to develop skills in communicating and relating with a diversity of people.

1.2.6 Breadth and Depth of Education

The need for a broad engineering education is more pronounced than ever. Engineers today must be conversant in increasingly diverse fields of technology, while at the same time demonstrating business and managerial acumen. As mentioned previously, they must also understand the ethical, social, environmental, and global implications of engineering decisions.

The factors acting to broaden the field of engineering will likely effect many changes in the way engineers are educated. Nevertheless, the technical depth of engineering education cannot be compromised. The world will continue to rely upon technically competent engineers to provide leadership and technological development. The advent of computers and automation, for example, has not diminished the necessity for engineers and other professionals who excel in technical knowledge and skills. Engineering curricula should concentrate on providing in-depth education in a few core areas of expertise, while at the same time delivering broad exposure to a wide array of disciplines [49-51, 53, 55]. Successfully striking the balance between breadth and depth will prove to be a challenge for engineering education in the years to come.

1.2.7 Life-Long Learning

In light of increases in competition and the accelerated pace of business, life-long learning will be a necessity for the engineering career of the future. As mentioned previously, the "educational half-life effect [37]" implies the need to constantly update one's skills and knowledge. Therefore, during their university years, engineering students must begin to take ownership of their education and develop the motivation and ability to learn by themselves [49, 51], and to do so throughout their careers [50, 53-55]. It is also the responsibility of the university to instill these qualities in students.

Perhaps more than any other single skill, self-initiated learning is critical to the future success of engineering students. As an old proverb says, "*Give a man a fish, and he eats for a day. Teach a man to fish, and he eats for a lifetime* (source unknown)." If graduating engineers understand the importance of life-long learning, universities will have gone a long way toward producing competent, professional engineers for the marketplace of the future.

1.2.8 Assess Student Learning

Educational programs must assess the outcomes of their efforts and use that feedback to improve the process. Of course, as in any measurement procedure, institutions must be careful to measure the *right* outcomes. Since the goal of education is to produce learning in students [57], assessment must be based on the measurement of student learning increases. Though this may seem obvious, many institutions still assess faculty performance "in teaching terms, not learning terms [57]." When institutions are compared with one another, usually the comparison is based primarily on resource inputs (number of Ph.D.s on the faculty, research dollars spent each year, etc.), rather than on student learning outputs [57].

ABET's upcoming *Engineering Criteria 2000* requires engineering programs to utilize student-learning-based outcomes assessment. An excerpt from the third criterion in ABET *Engineering Criteria 2000* reads as follows [56]:

Criterion 3. Program Outcomes and Assessment

Engineering programs ***must demonstrate that their graduates have***

(a) an ***ability*** to apply knowledge of mathematics, science, and engineering
(b) an ***ability*** to design and conduct experiments, as well as to analyze and interpret data
(c) an ***ability*** to design a system, component, or process to meet desired needs
(d) an ***ability*** to function on multi-disciplinary teams
(e) an ***ability*** to identify, formulate, and solve engineering problems
(f) an ***understanding*** of professional and ethical responsibility
(g) an ***ability*** to communicate effectively
(h) the broad education necessary to understand the impact of engineering solutions in a global and societal context
(i) a ***recognition*** of the need for, and ability to engage in life-long learning
(j) a ***knowledge*** of contemporary issues
(k) an ***ability*** to use the techniques, skills, and modern engineering tools necessary for engineering practice

* *Emphasis added.*

This brief excerpt from *Engineering Criteria 2000* demonstrates that student-learning-based outcomes assessment must be an integral part of any educational course or program in engineering.

1.3 High-tech Entrepreneurship

In response to the myriad challenges facing American engineering education, many courses of action could be taken. Clearly, no approach will be a panacea; nevertheless, some approaches will be better than others. I suggest that one of the best ways to equip students to thrive in the marketplace of the future is to **teach innovation in the context of entrepreneurship**.

1.3.1 Why Teach Entrepreneurship?

Few would argue with the assertion that the development of innovative future engineering and business leaders is a worthwhile objective. Certainly every faculty member at every university would like to ensure that their students learn to identify new business opportunities and that they have the wherewithal to capitalize on those observations.

However, there seems to be some disagreement over the assumptions that underlie the concept of innovation. What is innovation? Can it be *taught*? Can it be *learned*? Can people be innovative *intentionally* and *consistently*?

Webster defines innovation as "the introduction of something new; a new idea, method, or device." This definition, though insightful, does not touch upon *how* one goes about being innovative. Peter F. Drucker, one of the world's most respected authorities on management, provides the following excellent working definition:

> **Innovation**: *the exploitation of change as an opportunity for a different business or a different service* [59, p. 19].

He argues that this exploitation of change *is* intentional and that it *can* be taught and learned. In his 1985 book *Innovation and Entrepreneurship*, he says the following about innovation:

> *...whereas much of today's discussion treats entrepreneurship as something slightly mysterious, whether gift, talent, inspiration, or "flash of genius," this book represents innovation and entrepreneurship as* ***purposeful tasks*** [59, p. vii] . . . *Innovation is the* ***specific tool*** *of entrepreneurs, the* ***means*** *by which they exploit change as an opportunity for a different business or a different service.* ***It is capable of being presented as a discipline, capable of being learned, capable of being practiced*** [59, p. 19, emphasis added].

Thus, according to Drucker, who has studied entrepreneurship for over thirty years, innovation can be taught, learned, and practiced. In fact, the remainder of his book describes clearly why and how professionals of the future can and *must* practice innovation as the "specific tool of entrepreneurs."

Entrepreneurship, as defined by Webster, is the process of organizing, managing and assuming the risks of a business or enterprise. However, this definition does not encompass the full range of meaning currently given to this term. I propose the following broader definition:

> **Entrepreneurship**: *intentional activity aimed at meeting a perceived need through the creation of innovative methods, processes or products; and, subsequently, envisioning, organizing, managing, and assuming the risks of a new enterprise or business.*

I recommend the teaching of entrepreneurship in light of evidence that the majority of new jobs are created by small businesses, which tend to rely on entrepreneurs. Birch, a leading researcher in the field of employment and job creation, indicates in a 1987 study that "contrary to some popular opinion, smaller firms are more than capable of offsetting their higher failure rates by their ability to organize and then grow [60, p 16]." In an earlier study in 1979, Birch states [61, p 29]:

> *"The results tell a clear story. On the average about 60 percent of all jobs in the U.S. are generated by firms with 20 or fewer employees, about 50 percent of all jobs are created by independent, small entrepreneurs. Large firms (those with over 500 employees) generate less than 15 percent of all net new jobs."*

Therefore, it is clear that entrepreneurship can help create jobs in the context of small companies. This does not imply that students should not be encouraged to work for large companies as "intrapraneurs;" rather, it indicates that students must see small business as a viable option and be given the skills necessary to pursue such a career.

1.3.2 Why *High-Tech* Entrepreneurship?

More specifically, however, I recommend that engineering education should focus its efforts and resources on ***high-tech* entrepreneurship** as one of the best means to develop qualified engineering professionals. I make this distinction because traditional definitions of entrepreneurship can include non-technical innovations as well as endeavors requiring no innovation at all. For example, the classical definition of entrepreneurship can include opening a drive-through supermarket or starting a lawn mower repair business. These enterprises are worthwhile and valuable in their own right. Nevertheless, engineering education should incorporate innovative entrepreneurial activity focusing on technology-intensive problems and solutions.

High-tech entrepreneurship holds great potential as an educational medium because it is a broad topic that addresses many of the weaknesses and challenges facing engineering education.

Entrepreneurship demands innovation on the part of those who would practice it. Because entrepreneurship focuses on the *implementation* of innovative concepts, it will expose students to real-world issues, requiring the application of broad cross-disciplinary knowledge and skills. Students in an entrepreneurial program (as I envision it) must be active participants in their learning experience, working together in diverse teams to accomplish common objectives. Furthermore, by focusing on technology-intensive problems and solutions, students will gain skill in working with many high-tech, information-intensive issues. Finally, students in such a program should be exposed to the global context in which they will do business.

Educational programs focused on high-tech entrepreneurship could take many forms. In order to flesh out a program designed specifically for the modern American University setting, it is appropriate to consider some of the relevant trends in academe.

1.4 Relevant Trends in Academe

There are two noteworthy trends in academe which come to bear upon our discussion of the need for a new kind of educational program. First, there is the realization that research and teaching need not be considered irreconcilable enemies. Second, there is also a growing concern about the overabundance of publications. These trends establish the relevance of my suggestion that the generation of intellectual property should be viewed as a valid academic and educational pursuit. The connection between the generation of intellectual property and the teaching of innovation will be made clear in Section 1.4.3.

1.4.1 Teaching Versus Research?

The academic community has long found itself embroiled in a seemingly endless debate pitting teaching against research. Ernest Boyer, of the Carnegie Foundation for the Advancement of Teaching, however, points out that this debate is fundamentally misguided [62, xii]:

> *The most important obligation now confronting the nation's colleges and universities is to break out of the tired old teaching versus research debate and define, in more creative ways, what it means to be a scholar.*

In his 1990 special report, Boyer suggests a broadening of the definition of scholarship to include four sub-categories: discovery, integration, application, and teaching. He argues that each of these areas should be viewed as equally valid forms of scholarship and that professors be given freedom to concentrate in any or all of these scholarly activities. His definitions of these terms can be summarized as follows [62]:

> **Scholarship of Discovery**: This is what is traditionally considered as basic research. Activities are aimed at answering the questions: "What is to be known, what is yet to be found? [62, p. 19]"
>
> **Scholarship of Integration**: This form of scholarly activity includes fitting things together in the context of a major field, identifying relationships to other fields, and seeking to connect seemingly unrelated areas of knowledge in ways that bring new discoveries and understanding. Thus, such scholarship seeks to answer the question, "What do these findings mean? [62, p. 19]"
>
> **Scholarship of Application**: This area of scholarship involves finding ways to make newly discovered and developed knowledge work for industry and society. Those pursuing this form of scholarship seek to answers to the questions: "How can the knowledge discovered and understood in its broader context be applied to consequential problems? Can social problems themselves define an agenda for scholarly investigation? [62, p.21]"
>
> **Scholarship of Teaching**: When viewed from the right perspective, teaching can be a very valid form of scholarly activity. Student questions and comments should push the faculty back into the lab to more thoroughly understand the matter or even to investigate previously unconsidered factors. Additionally, "when defined as scholarship...teaching both educates and entices future scholars. [62, p. 23]"

In light of what has been suggested by Boyer, I offer that research and teaching need not be at odds. In fact, to pit one against the other misses Boyer's main point: that a proper view of scholarship encompasses both basic research *and* teaching (as well as the integration and application of knowledge), and that faculty should be encouraged to emphasize these elements to varying degrees throughout their careers. In this way, maximum faculty productivity and satisfaction can be achieved, along with maximum gains in student learning.

1.4.2 Too Many Publications

Few would argue with the statement that too much emphasis in the academic world is placed upon publishing. The cliched phrase "publish or perish" implies an imbalance in the importance attributed to published work, particularly in terms of achieving tenure. Two *Science* magazine articles by David Hamilton created quite a stir by pointing out that 55% of supposedly scholarly scientific papers remained uncited years after their publication [63, 64]. Hamilton's assertions were based on statistics compiled by the Institute for Scientific Information (ISI). David Pendlebury, the ISI analyst who originally supplied the figures to *Science*, followed up those articles with a letter to the editor of *Science*. He urged that those figures be interpreted with caution and that they not be used as a measure of the health of the American research establishment. According to Pendlebury, "a certain level of 'uncitedness' in the journal literature is probably more an expression of the process of knowledge creation and dissemination than any sort of measure of performance [65]." He closed his letter with the hope that it "will end further misunderstanding or politicalization of these statistics. [65]."

No matter how one interprets these statistics, the perception remains among the academic community that there is too much emphasis placed on one's publication record. A 1989 National Survey of Faculty (by the Carnegie Foundation for the Advancement of Teaching) demonstrates this point convincingly. In this survey, Boyer indicates that 81% of engineering faculty believe that it is difficult for a person to achieve tenure without publishing. In fact, 83% believe that the *number* of publications is important as a tenure requirement. Only 50% of engineering faculty indicated that published work *is* evaluated for its *quality* and not merely counted for its quantity. Sixty-three percent of engineering faculty did stress the importance of the reputation of the press, journal or book in which the publication appears. However, 81% of engineering faculty respondents espoused the view that "at my institution we need better ways, besides publications, to evaluate scholarly performance [62, Table A-5]."

1.4.3 Generate Intellectual Property

In light of the recognized need to broaden the definition of scholarship and the perceived overemphasis on publications, I suggest that the generation of intellectual property be recognized and rewarded as a valid measure of creative, scholarly activity. I do not recommend a wholesale abandonment of the publication of research, but, rather, that the generation of intellectual property be viewed as a viable academic enterprise on par with publications.

Though this recommendation may seem unorthodox to some, similar views have been stated previously in the literature. Robert Linnell, in 1982, wrote, "the institutional reward system should explicitly recognize intellectual properties...as contributions which merit equal consideration to that of teaching and basic research [66, p. 100]." Kenneth Waldron, in a speech given at the ASME Design Engineering Technical Conference (reprinted in *Mechanical Engineering*), scolded mechanical engineering faculty for thinking of themselves as scientists and not as the engineers that they really are. He explained that because engineering faculty mistakenly see themselves as scientists, they tend to disdain design, instead favoring the pursuit of more "scholarly" (read scientific) activities. He urged his fellow engineering faculty members to think of themselves primarily as engineers, to be proud of that fact, and to start valuing creative synthesis as an intrinsically valuable activity worthy of recognition and reward [67].

I suggest that just as publication is the appropriate culmination of basic research efforts, that the generation of intellectual property should be viewed as the equally appropriate culmination of creative, synthetic (design) efforts. The benefits of recognizing and rewarding the generation of intellectual property are numerous. It can potentially increase faculty productivity and satisfaction by providing more freedom in determining their most effective modes of contribution. The opportunity to share in the profits of commercialized intellectual property also promise to be rewarding for faculty. In light of increased public scrutiny and decreased public funds available, effectively commercialized intellectual property also helps generate wealth for the university, thus maximizing the return on (taxpayer) investment in the university. Along these lines, intellectual properties can also provide the university with an additional and much needed source of discretionary funds. Finally, assuming that students could participate in the generation of intellectual property, the education of students could take place in concert with the pursuit of faculty scholarly objectives.

Therefore, I suggest that intellectual property generation be viewed as a means to simultaneously accomplish both educational *and* scholarly objectives. It remains to be seen if a feasible educational program can be developed that would transform students into entrepreneurs as they work together with faculty members to generate intellectual property.

1.5 High-Tech Entrepreneurship Programs Nationwide

Entrepreneurship is certainly not a new concept in American higher education. Vesper [68] reports steady growth in the number of universities and colleges offering at least one course in entrepreneurship (defined as business entry). In 1967, there were only a handful of such schools; in 1980, the number had risen to more than 150; and in 1991, there were over 300 domestic programs and a growing number of programs worldwide.

According to Vesper's survey results, the nature of the courses and programs offered in entrepreneurship vary widely. They range from individual courses to entire degrees. They differ in the extent to which they incorporate both business and engineering issues. And, they vary in the extent to which they involve a diversity of participants, particularly both engineering and non-engineering students [68].

In light of such a proliferation of curricula that include entrepreneurship, it is imperative to narrow the range of programs to be evaluated. The ideal high-tech entrepreneurial program, by my definition, would be a multi-year, cross-disciplinary, hands-on student involvement program. In this program, students would "learn by doing" in teams both in and out of the classroom to address high-tech entrepreneurial issues. Furthermore, intellectual properties generated by the program should provide the University with some level of revenue.

Despite the large number of entrepreneurship programs reported by Vesper [68], few programs are similar to my definition of an ideal program. (In fact, the several programs that bear some similarity to my definition were not even mentioned by Vesper). Comparisons of these programs at several points are provided in Tables 1 and 2. More detailed summaries of these programs are given in Appendix A.

The programs that bear the greatest similarities to this definition are the Engineering Entrepreneurs Program at North Carolina State University [69, 70] and the Envisioneering™ Program at Penn State [71]. These programs are multi-disciplinary student-involvement programs focused on innovation and hands-on entrepreneurship. The Entrepreneurship Program at the University of Iowa [72], though not a project-oriented student-involvement program, involves an excellent curriculum, offering entrepreneurship courses to students from any major. This Program even offers a "Technical Entrepreneurship" course concentration specifically for engineering majors.

Several other programs have also been listed in Appendix A. Though not necessarily similar to my definition of an ideal program, these programs are each noteworthy. The Engineering Research Center at Purdue [73] is an excellent example of an industry-driven program involving interdisciplinary teams addressing real-world problems. The Learning Factory at Penn State [74] provides a model for the level of collaboration and momentum that can be achieved by a well-run educational program. The Learning Factory, a product of the Manufacturing Engineering Education Partnership, involves three universities working together with over 100 industrial partners [74]. The Engineering Design/Analysis Course at the University of Nevada at Reno [75] provides a superb example of what just one course in entrepreneurship can accomplish. Student teams work during one semester to design and build an electronic device of some sort. Several of these designs have turned into real products that were sold to existing companies or even formed the basis for new start-ups.

Consideration of these programs was helpful in the development of an entrepreneurial program concept that could be implemented at Virginia Tech. Nevertheless, I have not yet discovered any entrepreneurial education programs that emphasize the development and commercialization of intellectual properties by students. Nor, to my knowledge, do any programs emphasize their financial benefits to the university. In these two regards, it appears that my definition of an ideal entrepreneurship program may not yet have been realized. This concept, which I have called the Creative Entrepreneurs Organization, will be discussed in Chapter 2.

Table 1. Comparison of Programs and Participants in Entrepreneurship Programs Nationwide

Program Name (School) [references]	**Program comprised of courses, team projects, or both?**	**Undergraduate Involvement *(Majors)***	**Undergraduate Involvement *(Academic years)***	**Graduate Involvement**
Engineering Entrepreneurs (NC State) [69, 70]	Team projects.	Electrical and Computer Engineering.	Freshman through senior years.	Not mentioned in literature.
Envisioneering™ (Penn State) [71]	Team projects, though courses will also be offered soon in an "Engineering Leadership Minor."	Any engineering major.	Freshman through seniors years.	Not mentioned in literature.
Entrepreneurship Program (U. of Iowa) [72]	Courses.	Business (or MBA), non-business, Healthcare, engineering tracks available.	Sophomore through senior years.	Yes.
Engineering Research Center (Purdue) [73]	Team (research) projects.	Interdisciplinary (unclear exactly which majors participate). Faculty participation appears more significant than that of students.	Unclear.	Probable, but not mentioned in literature.
The Learning Factory (Penn State) [74]	Courses and team projects.	Industrial, Mechanical, Electrical, Chemical Engineering, and Business.	Freshman through senior years.	Not mentioned in literature.
Engineering Design/Analysis Course (U. of Nevada, Reno) [75]	One senior-level capstone course (in which students work in teams on projects).	Electrical Engineering students.	Senior year.	No.

Table 2. Comparison of Product Development in Entrepreneurship Programs Nationwide

Program Name (School) [references]	**Type of products developed**	**Are these products developed and sold to real customers?**	**Where do product concepts initiate, primarily?**	**Intellectual property development emphasized?***
Engineering Entrepreneurs (NC State) [69, 70]	Specific categories, such as "Portable Medical Devices," "Multimedia Software," "Mechanical Engineering Courseware," and others.	It appears so, though not stated specifically in the literature.	Faculty advisors choose company themes. Students develop concepts within those areas. Some products suggested by industry.	No.
Envisioneering™ (Penn State) [71]	Educational products for the engineering curricula.	No. (These products are developed, but then supplied freely to the University).	Unclear, though close involvement with industry partners is emphasized.	No.
Entrepreneurship Program (U. of Iowa) [72]	None. (Program is course-based).	N/A	N/A	No.
Engineering Research Center (Purdue) [73]	Various. Depends on industrial needs.	No.	Industry partners.	No.
The Learning Factory (Penn State) [74]	Various. Recommended by industry partners.	No.	Industry partners.	No.
Engineering Design/Analysis Course (U. of Nevada, Reno) [75]	Various electrical circuits and devices.	Not usually. (A few have been marketed to real customers).	Student teams.	No.

* This column refers to whether or not the program *intentionally* strives to generate intellectual property.

Chapter 2

Creative Entrepreneurs Organization: Developing Innovative Products and Businesses

2.1 Criteria for a Successful Program

In light of the above discussion, it is clear that any new educational program must meet several criteria. Ideally, such a program would produce engineering professionals, well equipped to compete in the fast-paced, high-tech marketplace of the future; facilitate the creation of profitable university intellectual property; encourage faculty members to mentor students working to generate intellectual property; and, create revenue for the university.

It remains to be seen whether a program can be developed that would satisfy all of these criteria. This chapter is an attempt to lay out one such feasible realization: the Creative Entrepreneurs Organization: Developing Innovative Products and Businesses (CEO Program).

2.2 CEO Program Overview and Details

The Creative Entrepreneurs Organization will be a student-involvement program that will transform students into successful innovators and entrepreneurs as they work to create marketable intellectual property. Students will develop entrepreneurial skills and confidence as they work in small, cross-disciplinary teams to generate, evaluate, develop, and market their own intellectual property concepts. Faculty members will be encouraged to participate as student team mentors and as co-inventors with students. Ideally, after some initial start-up period, the CEO Program will generate revenue for the University, at least partially defraying the costs associated with its operation.

At the beginning of the fall semester, all CEO students (from various colleges and academic years) will generate a large spectrum of potential product categories. Students will then form teams of roughly five to eight people based on product interests, personal relationships, group skill set, and other factors. These small teams will work together to generate potentially marketable intellectual property product concepts.

Each student team will then take its idea(s) and perform preliminary market analysis and patent research. Within a few months, the teams must persuasively present their product concepts to the CEO Program Evaluation Team (comprised of seniors, graduate students, and faculty). As part of this presentation, each team must specify objectives to be met by the end of the academic year. These objectives, once accepted by the Evaluation Team, will be used as grading criteria at the end of the academic year.

The overriding objectives for every team and every project will be to create, protect, and market new intellectual property. Nevertheless, the steps taken to accomplish these objectives will vary from product to product. Additionally, it is likely that some products may take several years to bring to completion. Therefore, intermediate, product-specific objectives must also be specified at this stage.

Once the Evaluation Team has accepted each team's project concepts and specific objectives, the student teams will develop their products throughout the academic year. This will involve further market research and patent searches as well as product-specific development. This phase of the Program will involve students in many engineering and business issues.

At the end of the academic year, student teams will be evaluated on the degree to which they have satisfied the objectives agreed upon at the beginning of the year.

Once students determine that their product concept may be worthy of a patent application, they will be given the option of disclosing their invention to the University. While they are not necessarily obligated to disclose to the University, most students will probably wish to do so. As part of the disclosure process, all co-inventors (students, faculty, or whomever) must agree to the relative contributions made by each individual. In cases where disputes arise, they can be settled via an arbitration process supervised by the University's Intellectual Property Committee.

Product protection and marketing will take place in accordance with the University's existing policies and procedures. Specifically, the CEO Program will partner with Virginia Tech Intellectual Properties, Inc. (VTIP). Likewise, recognition and profit sharing for faculty and students will take place according to the established University intellectual property policy.

The timeframe assumed for the implementation of this Program is roughly five years from the time of this writing. This assumes that there is sufficient interest and "buy-in" from the

University and that enabling funds are available within this time period. It is expected that the effects of the CEO Program will be felt for several decades from its implementation, as participants apply what they learn throughout their careers.

2.2.1 Product Development

The success of the Virginia Tech Creative Entrepreneurs Organization Program hinges on the generation of marketable intellectual property. The process of taking a creative idea from initial conception all the way to market is called **product development**. This process is vast in scope and includes ideation, market research, product evaluation and selection, detailed design and development, product protection, and commercialization [76, 77]. Though listed sequentially here, ***these steps are often interrelated and iterative***. Each aspect of the product development process will be briefly described below, followed by an explanation of how each phase could be addressed in the CEO Program. Refer to the following flow chart (Figure 1) for an overview of this process.

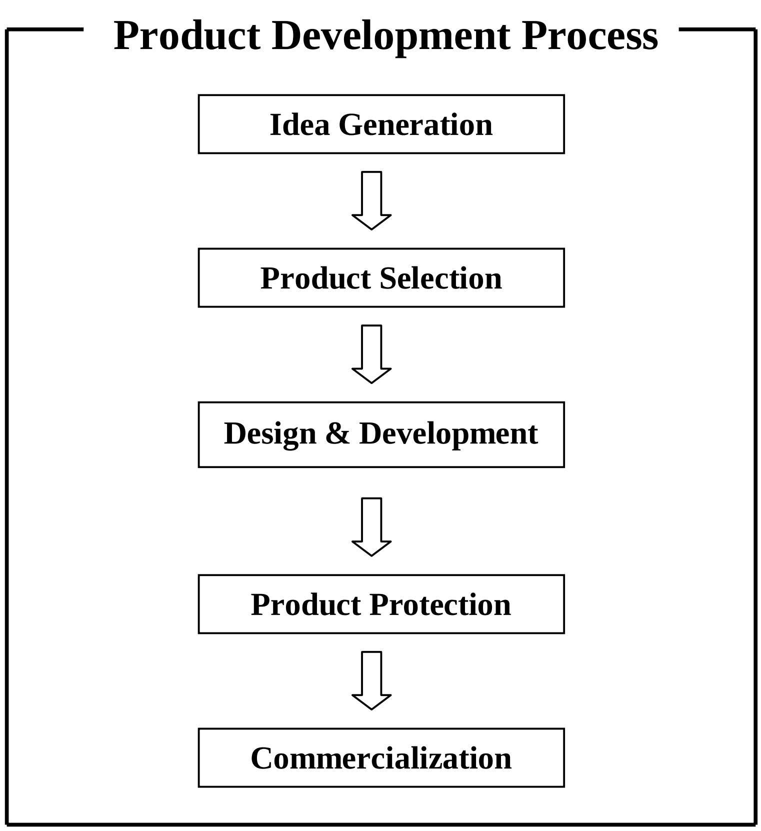

Figure 1. Product Development Process Overview

2.2.1.1 Ideation

Ideation refers to the generation or identification of new ideas. In the context of the CEO Program, it refers more specifically to the generation or identification of potentially marketable intellectual property concepts. The two primary ingredients of ideation are the people and the processes involved in generating those new concepts.

People: The lifeblood of the CEO Program is a steady stream of creative, potentially marketable product ideas. Therefore, it is fitting that those ideas be generated by the University's most creative human resources: students and faculty members.

The CEO Program, by its very nature, will tend to attract highly motivated, enterprising students. Such participants are an ideal source of potentially marketable, creative product concepts. The chief advantage to idea generation by participating students is obvious - students will be highly motivated to pursue their own ideas, especially where the potential for recognition or reward exists. In the CEO Program, the potential rewards for successful products are real and tangible; students can actually co-author patents or licenses and even receive royalties. Financial motivation notwithstanding, the opportunity to learn real engineering skills while working on one's own ideas should hold great appeal for many students.

On the other hand, the drawback to relying on students as a source of product concepts is that many ideas may simply be unfeasible. Student-generated concepts may fail due to incomplete market analysis, infringement on existing product patents, failure to consider significant hidden costs, or for a number of other reasons. However, the failure of student-generated concepts can be constructive, provided that the Program administrators and student leaders encourage constructive reflection on failures. Failure can often teach much more than success. For this reason, it is the opinion of the author that the advantages of the creative energy brought to the Program by students willing to think "outside the box" far outweighs the drawbacks associated with ideas and products that do not succeed.

Along these lines, it will be necessary to stimulate student participants to develop their creative skills. Traditional high school and engineering curricula often stifle innate creativity, demanding that students come to *the* correct solution to every problem. After several years' immersion in such a stultifying environment, it may initially be difficult for some students (particularly upperclassmen) to be willing to generate and stand behind their own original solutions to open-ended problems. Therefore, the CEO Program must encourage students to think creatively. This encouragement can take the form of creativity exercises and lectures. Ideally, these efforts would take place in the context of a broader paradigm shift among educators to nurture creativity in students rather than stifle it. Effecting such a paradigm shift is, of course, far outside the realm of this work.

A second significant source of ideas will be faculty members. Many faculty members have ideas for potentially marketable products. Unfortunately, when these ideas are not a part of funded research, faculty may lack the resources with which to pursue them. The CEO Program could provide a welcome outlet for those creative energies. Faculty, working together with students in the Program, could be enabled to pursue some of their ideas all the way to commercialization. Reward and recognition will be given the faculty via patent recognition, royalties, publications, and recognition from their departments.

An additional benefit of this source of product concepts is that the ideas generated by faculty will tend to be more feasible and well targeted than many student-generated ideas. After spending years involved in research and teaching in an area of expertise, a faculty member is often able to see specific needs and envision potential products to meet those needs.

Processes: The processes most often used for the generation of ideas include brainstorming, checklists, attribute listings, morphological analysis, and trigger response, to mention a few [76]. All of these processes involve a group of people who suggest anything that comes to mind in the context of a particular issue, feed off of one another's ideas, and seek to create a large list of potential products in an environment free of criticism.

At the beginning of the fall semester, all CEO students (from various colleges and academic years) and faculty participants will generate a large spectrum of potential product categories. Students will then form teams of roughly five to eight people based on product interests, personal relationships, group skill set, and other factors. These small teams will work together to generate potentially marketable intellectual property product concepts. In order to generate those concepts, students should be encouraged to utilize brainstorming sessions, attribute lists, and the other approaches mentioned above. It will be important to encourage students to be careful to consider the perspective of the customer in generating product concepts. Along these lines, informal interviews with potential customers could be useful in generating relevant product concepts.

One concern with group brainstorming-type approaches is that the potential for ownership disputes exists. It will be necessary to carefully document these product concept generation sessions. It may be that recording the sessions (on audio or video tape) may be the best way to accurately document the generation of new intellectual property concepts. Students must also be informed of their rights and responsibilities regarding the generation of intellectual properties. They must keep accurate log books and document their work carefully to protect their rights. Once a concept has been developed to the point that a disclosure is appropriate, these student records will be critical in assessing claims regarding ownership and in determining an equitable division of potential revenues.

The emphasis during the ideation phase will be on encouraging creativity and avoiding any criticism of ideas. Once the list of needs and potential products has been developed, each concept will then be evaluated briefly, considering such things as student interest in the project, strengths and weaknesses of the concept itself, etc.

By the end of this process (which will take more than one meeting), each student team should have at least one potentially workable project. Once this process has been completed, the student teams can begin their market and product research, preparing to present and defend their ideas before the Program's Evaluation Team.

2.2.1.2 Preliminary Market Research

Once potential products have been identified, the student teams will perform preliminary market and product research. During this phase, it will be necessary for students to do the following:

- Perform patent searches. (These will be limited in scope, but should be well documented to avoid duplication of efforts later in the product development process).
- Consider demographic and customer factors.
- Identify competing products.
- Establish a preliminary timeline and objectives.
- Estimate the resources necessary to accomplish the stated objectives.

- Address any potential problems that may arise. (That is, identify potential problems foreseen and suggest strategies for addressing each one).

It should be emphasized that, at this stage, only preliminary research will be conducted; after the Evaluation Team has selected the projects with the greatest potential for success, more thorough market research will be conducted.

2.2.1.3 Product Screening and Selection

Once potentially feasible ideas have been generated and market analysis has been performed, product concepts must face the product screening and selection phase.

One possible methodology for the evaluation of ideas is to establish an Evaluation Team to which student teams or faculty present their concepts in an oral presentation format, though a written report could also be required. The Evaluation Team should be made up of students with prior experience in the CEO Program, preferably juniors, seniors, and graduate students. Ideally, there would be at least two faculty members on the Evaluation Team to provide guidance: one from the College of Engineering and one from the College of Business.

As the presentation of intellectual property concepts could be an enabling disclosure, it may be necessary for all participants to sign confidentiality agreements. Although industrial involvement in the Evaluation Team could bring a “real-world” perspective, confidentiality concerns may override. Therefore, it may be better to recruit the involvement of University personnel with industrial experience rather than to seek the direct involvement of industrial representatives.

The Evaluation Team will critique the concepts according to previously established criteria. This step in the process should be thought of as the filtering process in which only those ideas with the greatest potential for success are allowed to pass. The evaluation criteria should include consideration of the product, the external environment, and the CEO Program itself. These factors, though listed separately, are intimately interrelated. Below is a suggested list of factors relevant to product evaluation:

Product factors:

- manufacturability, manufacturing costs
- raw material availability

- size, shape, materials of construction, color
- price (How much would we have to charge to recoup development costs? Would the market bear such a price?)
- projected sales volume
- profitability (With realistic assumptions, how much profit can be expected? Over what period of time? How long before all costs could be recovered? What is the product's sales life expectancy?)
- adaptability to customer needs
- marketing strategy and estimated cost

External factors:

- market size (existing or potential)
  - domestic
  - international
- market constituency (Who are the potential customers? Do they desire such a product?)
- competition (existing and potential)
- existing demand vs. marketing (Does the product meet an obvious need or want? Or, would extensive marketing be necessary to convince potential customers of the value of the product?)

Internal (CEO Program) factors:

- mission (Does this product fit the CEO Program's "corporate" mission or objectives?)
- resources available
  - people (number, strengths, availability, desire to work on the product and its development)
  - financial
  - equipment
  - time (how many person-hours are available)

Using a set of evaluation criteria such as those listed above, the Evaluation Team would critique and "grade" each product concept. It is likely that no product concept will excel in every area, nor will many concepts fail across the board. Rather, each product will have a unique combination of strengths and weaknesses, making comparison of product concepts a difficult task. Though it is inherently difficult, product evaluation is absolutely critical to the success of the CEO Program and the education of the students. Precisely because of the rigor involved in evaluating concepts, this phase will be one of the most valuable aspects of the Program, in terms of developing judgement and decision-making skills in the students. Students who learn how to successfully evaluate potential product concepts will be well on their way to becoming savvy businesspeople and entrepreneurs.

In order to maximize the educational value to the students, the Evaluation Team should present the reasons for the selection of the concepts chosen, as well as recommendations for improvement of the concepts not selected. This feedback is necessary to turn a "failure" into a very valuable learning experience for the teams whose ideas were not selected. Not only can this feedback assuage feelings of disappointment, it can also provide the teams with areas of improvement so that this year's failures can be turned into next year's successes.

2.2.1.4 Product Design and Development

Once product concepts have been generated, evaluated, and selected, the work of actually designing and developing the product can begin. In some cases, such as when a faculty member submits an idea, many of the technical details may have been previously considered. However, the majority of the product concepts will be those which have not been previously considered, and thus may entail a significant investment of time (and, possibly, of money as well).

The Evaluation Team will work with individual student teams to refine and agree upon specific objectives for the development of their concepts. It is also recommended that a timeline be developed and agreed upon (by the Evaluation Team and the specific student team). This will guide the development of the intellectual property concept and provide criteria against which the team can be evaluated and graded at the end of the academic year.

The details surrounding the design and development of a particular product is intimately related to the nature of the product. Therefore, few generalizations can be made that apply to all products, regarding the resources necessary to complete them. Some products may take one student team only a semester or two to complete; others may involve several teams of students working over the course of years.

One generalization that can be made regarding all products is that a prototype must be generated. This could take the form of a hardware realization of the product concept, computer code, and so forth. The nature of the prototype will be dictated by the nature of the product. However, in order to provide students with a product realization experience and to facilitate the patenting process, a working prototype ("proof of concept") must be generated. This must be included in each team's objectives and appear on the timeline for the development of their product concept. Additionally, in order to satisfy the ABET design criteria (for mechanical engineering curricula) [78], the Mechanical Engineering Department would like to include all student in some form of product realization. Therefore, if students are to participate in the CEO Program for senior design credit, they must develop their product into a prototype or other form of realization. For this reason, the CEO Program Advisor must carefully screen the projects involving seniors, to ensure that each senior will be able to experience product realization.

Developing product prototypes will require the use of some discretionary funds to cover the cost of materials, parts and manufacturing equipment usage. After some start-up period of several years, revenue from successfully commercialized intellectual properties could be directed back into the CEO Program and used to defray product prototyping costs. In the mean time, however, prototyping expenses must be covered by some sort of external funding. Potential sources of seed funding for the CEO Program are discussed in Section 3.4.

2.2.1.5 Product Protection

Protection of the products and intellectual properties generated by the CEO Program is essential to the success of the Program. Fortunately, Virginia Tech has well-established mechanisms for the protection of new intellectual properties, via Virginia Tech Intellectual Properties, Inc. (VTIP). In general, students will likely elect to work in cooperation with VTIP to patent or copyright the new products they develop. (A more detailed discussion of VTIP and its proposed relationship to the CEO Program is given below in Section 2.2.1.8).

2.2.1.6 Commercialization

Once products have been conceived, selected, developed, and protected, they must be successfully commercialized. One of the most attractive and unique components of the CEO Program is that it is intended to become a financially successful endeavor, generating revenue for the University and for its participants; thus, successful commercialization of products is of paramount importance.

2.2.1.7 Literature Review

Transferring technology and disseminating knowledge have long been accepted and valued practices in American universities; seeking to commercialize such activities, however, is a somewhat newer and more controversial matter.

Throughout the past several decades, many universities have begun to commercialize the results of their research. Simultaneously, there seems to be a more fundamental shift, both within and without academe, toward viewing universities as commercial entities in their own right [58]. Much of the driving force behind this trend may be the increased pressure for profitability placed on the shoulders of the University in light of the reduction in federal and state funds [58]. Whatever the cause, the trend toward commercialization appears to be a lasting part of the modern academic landscape. Whether or not universities *should* be thought of as commercial entities, however, remains the subject of debate.

Those who oppose commercialization point to the compromise of the educational process to the detriment of the students and, ultimately, of society. Robert Ovetz, in his scathing critique of the international trends in universities toward commercialization, goes so far as to portray this trend as a subtle yet pervasive evil which threatens the global environment, economy, and the future wellbeing of students worldwide. In fact, he calls for radical resistance and rebellion on the part of students to turn the tide in the battle for the future of education and the world [58]. Most people, of course, do not take such an extreme view, but there is no doubt that the commercialization of universities is in many ways "an anathema to academic traditions, culture, and processes [79]." The concerns raised by opponents of commercialization of universities must, of course, be carefully considered. Certainly, the educational process must not be adulterated by the attempt to make a profit. American universities must continue to develop students into capable, qualified leaders for tomorrow's industry and society.

On the other side of the fence, however, one could point to the advantages of the commercialization of university research and development efforts. First of all, by actively seeking to market the intellectual property it generates, the university is forced to stay relevant to industrial needs. In addition, by generating some amount of revenue as a result of its efforts, the university can become less dependent on external funding. Finally, the very process of generating and marketing intellectual property that meets industrial needs can be an extremely valuable educational experience for the students involved in the process [80].

As universities engage in research and development activities with the intent of commercializing the results, they must beware of the inherent tendency to compromise their educational integrity and not succumb to "mission drift" [81]. Nevertheless, it is the opinion of the author that creativity on the part of educators may lead to the discovery of educational methods, courses, and programs that are financially responsible. This is, in fact, one of the premises and distinguishing features of the CEO Program.

2.2.1.8 Commercialization of Products at Virginia Tech

Students will gain valuable experience by participating in the commercialization process. Though the overarching goal of commercialization is the same at every company and organization, the actual mechanics of the process are usually unique to each institution. At Virginia Tech, both protection and commercialization of intellectual property take place in cooperation with Virginia Tech Intellectual Properties, Inc. (VTIP). VTIP, Inc., a Virginia Tech affiliate, exists to facilitate protection and commercialization of intellectual properties generated at Virginia Tech. The mission of VTIP is as follows [82]:

> *"to support Virginia Tech through maximizing the return to the University from its research investment by balancing the following:*
>
> - *income generated by licensing and other activities related to university intellectual property;*
> - *sponsored research funding from licensees;*
> - *creation of new or start-up businesses and jobs;*
> - *dissemination of university expertise to society."*

In order to assist the creators of intellectual property, VTIP and Virginia Tech's Office of Sponsored Programs have developed a four-phase process that covers intellectual property creation, assessment, protection, and marketing. Existing VTIP-University policies and procedures appear to be suitable for the protection and commercialization of intellectual properties generated in the CEO Program (see Appendix B). The exact nature of the Program's interaction with VTIP will have to be formalized as part of the implementation of the CEO Program.

2.2.2 Intellectual Property

Intellectual property creation is at the heart of the CEO Program concept. The potential for financial (and professional) reward should provide strong motivation for participation in the Program. Therefore, attention must be given to intellectual property ownership and profit sharing.

2.2.2.1 Ownership

Virginia Tech Intellectual Property Policy (included in Appendix C) clearly sets forth guidelines regarding the ownership of intellectual properties generated by faculty or students. When University employees (faculty or funded graduate students) using University resources generate new intellectual property, the "strong presumption of ownership is to the University [83]."

However, all intellectual property does not necessarily default to University ownership. Virginia Tech Intellectual Property Policy states the following [83]:

> *"IPs (Intellectual properties) generated by students not employed by the university and not using university resources of at least $10,000 in their generation will be owned by the student but subject to any applicable prior rights of private sector or governmental sponsors and to the right of the university to use the IP internally at no cost."*

Students are, therefore, not obligated to disclose potential intellectual properties to the University, unless they have utilized more than $10,000 in University resources. Therefore, it is possible that students will elect not to disclose their inventions to the University, leaving the CEO Program (and the University) "high and dry."

Nevertheless, when students realize that securing a patent can take up to two years and may cost $10,000 in legal fees, they will likely become more inclined to disclose to the University. Besides the costs associated with patenting one's own invention, the rewards of disclosure to Virginia Tech should prove attractive. University policy states that (co)inventors will receive 50% of the net revenue generated by the property (once legal, administrative and marketing costs have been deducted). Therefore, the prohibitive costs associated with patenting an invention on their own, combined with a generous profit sharing policy, should ensure that most students choose to disclose their inventions to the University.

2.2.2.2 Profit Sharing

In the case of intellectual properties disclosed to the University, those who have contributed to the development of the property have a right "to share in the benefits derived therefrom [83, p. 4]." According to current Virginia Tech policy, originators are entitled to 50% of the net revenue generated from intellectual properties. "Expenses to be subtracted from gross revenue before sharing shall be limited to documented direct and indirect costs for protection (patenting), marketing and development of the intellectual property [83, p. 6]."

In the case of intellectual properties generated by a team of inventors, the originators will share 50% of net revenue among themselves according to their relative levels of contribution. The exact share to be apportioned to each inventor must be negotiated by each team when they choose to make a formal disclosure to the University. It is significant to note that students and faculty share profits according to their relative contributions to the invention and *not* according to age, academic degrees held, or other such factors. Intellectual property policy (and law) protects the rights of all co-inventors. Therefore, students who work with faculty members on the development of an invention have every right to share in the profits that may result, provided that they demonstrate their contribution to its development.

It is recognized that the issue of profit sharing can become a point of contention. My recommendation is that all participants be informed, when they join the CEO Program, of their rights and responsibilities in the realm of intellectual property generation. All participants must keep careful records of their activities, in the form of engineering log books, for example. These records will become absolutely critical in the resolution of potential disputes and in claiming ownership of an invention. In the case where co-inventors cannot come to agreement regarding the relative contributions made by each member, the issue can be settled by an arbitration process under the jurisdiction of the University's Intellectual Property Committee.

One specific item of concern that relates to profit sharing is the potential for a "slave labor" situation to arise. This refers to situations in which students are not given adequate recognition or remuneration for their contribution to the development of an intellectual property. It is possible that some unscrupulous faculty members working with students in the development of an intellectual property could claim that the students did not make tangible creative contributions. In order to reduce the likelihood of such an unfortunate situation, students must be informed, at the very start of the Program, of their legal rights and responsibilities, and of the potential for a slave labor situation to arise. They must learn the importance of accurate, honest record keeping and about their rights to challenge the ownership claims of a faculty member (or of another student) in a legal environment in which neither age nor academic clout carries any weight.

The CEO Program has the potential to generate revenue for the University. Some of the revenue generated by the commercialization of an intellectual property will be directed back to Departments that participate in the Program, particularly to Departments making significant contributions of physical, financial and human resources. Virginia Tech Intellectual Property Policy states that "at least 10 percent of total net revenue may be distributed to the originator(s)' primary unit(s) (e.g. Departments, Centers, etc.) [83, p. 6]." In this way, the CEO Program can attract and reward the participation of various departments and colleges within the University.

2.2.3 Student Involvement

The CEO Program will be comprised of a diversity of students from various academic majors and levels. In keeping with its focus on high-tech entrepreneurship, the Program should primarily seek to attract students from engineering and business colleges, though motivated students from any department should be permitted to participate. In general, students can contribute in ways commensurate with their educational level and background.

There are several motivations behind encouraging a wide diversity of students to participate in this Program. First, it broadens the perspective of the students by exposing them to people who think differently. For this reason, it also facilitates the development of communications and interpersonal skills. Finally, it maximizes the number of students who will benefit from the CEO Program.

Though concerns could be raised about "diluting" the Program with unskilled and inexperienced students, I suggest that a high level of motivation (to learn and contribute) may outweigh deficiencies in experience and skills. Particularly in an educational environment where the goal is the development of engineers and businesspeople as professionals, allowances must be made for students without any prior product development experience. When considering students for leadership positions in the Program, skills and experience should definitely be considered; however, when recruiting new students, motivation ought to be the deciding factor.

Throughout the nation, there are a few entrepreneurship programs that include students from various academic majors [65, 69] as well as from various academic levels [63-65]. (For an excellent survey of entrepreneurship programs worldwide, I recommend a 1993 report by Vesper [62]).

In the College of Engineering at Virginia Tech, a wide diversity of students currently participates in various student-involvement programs with great success. The Autonomous Vehicle project, for example, has included students from a variety of academic majors: Mechanical, Electrical and Computer Engineering, Computer Science, Communications, and Forestry [84]. Additionally, freshmen are encouraged to participate in Senior Design projects as part of the *Introduction to Engineering* Course. Therefore, I recommend that students from all majors and academic years be encouraged to participate in the CEO Program, with special attention given to the recruitment of engineering and business majors.

2.2.3.1 Appealing to Students

As with all student involvement programs at Virginia Tech, the CEO Program will be voluntary. Therefore, it is imperative that it be attractive to potential student participants. The CEO Program should appeal to students by providing an excellent educational experience that will enhance their marketability upon graduation. Also, students will be attracted by the opportunity to develop their own ideas into real products. Since students share in the profits made on successful products, the potential for financial reward should prove to be an additional enticement.

2.2.3.2 Recruitment

Since the CEO Program is designed to be attractive to students, recruitment of highly motivated, enthusiastic participants should not be difficult. As the Program first gets underway, advertisement will be essential to inform students of this opportunity. One way to advertise the Program is for faculty or student leaders to make announcements in freshmen courses. CEO Program information booths could be set up at the large job fairs on campus, such as Engineering

Expo and Business Horizons. Key student professional organizations, such as ASME or Delta Sigma Pi, could be encouraged to spread the word to their members. Finally, mass-market-style informative flyers could be posted on bulletin boards around campus to reach the widest audience possible.

Once the Program has been up and running for a few years, the student participants themselves may do an excellent job in recruiting other students. This "students-recruiting-students" phenomenon has been found to be very successful in existing student-involvement programs at Virginia Tech. According to Professor Charles Reinholtz, advisor to the Autonomous Vehicle team, older students become recruiters, mentors, and informal course advisors as they seek to recruit and equip younger students to become future team leaders [84].

2.2.3.3 Teams

One of the primary components of the CEO Program will be the student team. Team-related issues have a significant impact on the success of a student program. Allen, *et al*., catalogues several common dysfunctions observed in student teams [85]:

- a "bad apple" who does not buy into the team or its objectives;
- a "know-it-all" student who dominates the team;
- passive students who do not make significant contributions;
- obsessive teams that are incapacitated by the fear of failure;
- in-fighting teams in which internal disputes prevent education and progress on the project.

Allen, *et al*., does not specifically mention corrective actions to remedy these dysfunctions, but indicates that such research may be underway [85]. A document used in a Mechanical Engineering course at Virginia Tech provides some helpful diagnostic questions related to group formation, behavior, and resolution of team-related problems [86]. Seat, *et al*., discusses the experimental use of external team coaches as a means of alleviating common team problems. The coaches meet with the teams and seek to promote clear communication and early resolution of potential problems. Seat, *et al*., reports that teams with coaches become "cohesive" faster and maintain that level of cohesiveness better than teams without such coaches. Future work will be done to determine if coaches also serve to improve student satisfaction [87].

One particular team-related issue that requires attention is ***team formation.*** That is, "How should students be assigned to teams?" and, "Should teams be formed first and then agree on projects, or should teams be formed around projects?"

Recognizing that the faculty Advisor should have the final say, I suggest that students be given the primary responsibility for forming themselves into teams based on their interest in particular types of projects. I recommend that students be encouraged to consider the following factors when forming teams: common interest in specific projects, existing relationships, academic level and skills represented, and team diversity.

Regarding the timeframe for team formation, I recommend doing so *after* some initial brainstorming has taken place. This will provide the students with an ample number of project areas from which to choose, thereby allowing teams to form around common interests. These suggestions about team formation come, in part, from comments made in the literature regarding entrepreneurial team projects. Writing from experience with the Envisioneer™ Program at Penn State, Andrew Milne writes, "instead of pre-ordaining what teams would exist...teams are now formed in response to project ideas [66]." Brawner and Miller, based on their experience with the Engineering Entrepreneurs Program at NC State, note that "teams formed of groups of friends (or fraternity brothers) appear to be more successful than others. [63]."

2.2.4 Faculty Involvement

The success of the CEO Program will rely on a significant level of faculty involvement. Therefore, it is imperative to address several issues related to faculty participation.

2.2.4.1 Appealing to Faculty Members

The CEO Program must attract faculty participants. In order to do so, involvement in this program must not conflict with the existing priorities placed on research and teaching. Ideally, involvement with the CEO Program would actually help faculty members simultaneously work toward both research and teaching objectives.

There are two primary ways in which faculty can be involved in this program: as overall Program Advisors and as individual student team mentors.

Ideally, there will be at least two faculty Advisors for the Program as a whole, one from both the engineering and business colleges. They will provide general Program oversight and mentor all student participants to some degree. These individuals must give high priority to their involvement in the CEO Program, seeing it as significant professionally and educationally. Though the total number of Program faculty Advisors will be small (probably two or three), their contribution to the success of the Program will be significant.

Faculty members may also wish to be involved as student team mentors. There may be faculty members who would enjoy the opportunity to stimulate student learning in a context such as this. Faculty involved with the CEO Program in this way must receive recognition from their departments for their involvement, even though it is a nontraditional form of interaction with students.

Faculty members from virtually any department can also be involved in the Program by suggesting their own product ideas for adoption by student teams. Once they "sell" an idea to a student team, these faculty members will act not only as team mentors but also as co-inventors. These faculty members can provide valuable technical assistance and the accountability necessary to ensure the success of their teams in terms of intellectual property generation *and* gains in student learning.

2.2.4.2 Recruitment

It is assumed that some faculty members will be attracted to the opportunity to guide a team of students in the development of products. Others may be inclined to suggest product concepts themselves and become co-inventors with a team of students. Therefore, it is likely that by publicizing the CEO Program among faculty throughout the University, significant interest and involvement can be generated.

It may take some "selling" on the part of the Program Advisors to attract faculty as mentors when the Program is still in its infancy. Some faculty may be hesitant to commit to a significant level of involvement in a new, unproven program. However, assuming that the Program starts small (say, 15 to 30 students), the involvement of just a few faculty mentors will be adequate to "prime the pump" and get the Program underway. Once the Program has been up and running for a year or two, more faculty members may see its potential value and decide to get involved.

2.2.4.3 Reward and Recognition

Faculty members involved in the CEO Program should be recognized and rewarded in ways commensurate with their involvement. Those who assist in originating, developing, and patenting new intellectual properties along with student teams will receive an appropriate share of any revenues generated. This will occur in accordance with published Virginia Tech Intellectual Property Policy. Specifically, the originators of intellectual property share 50% of (net) revenues earned [83]. Ideally, involvement in the creation of intellectual property will also be recognized as significant scholarly activity on par with publications [74, p. 100].

Likewise, involvement as a team mentor *should* be recognized as a valid teaching activity. It is particularly important that the individual departments formally recognize such involvement with respect to teaching loads, tenure requirements, and general contribution to the department. Refusal by departments to formally recognize faculty involvement in the CEO Program could jeopardize its success. Likewise, enthusiastic departmental recognition of faculty involvement will greatly facilitate the successful realization of the CEO Program.

2.2.5 Lecture Series

In order to maximize student learning, the CEO Program will include a lecture series featuring speakers from industry and academe. The Program could include one lecture per week, translating into roughly 25 to 30 lectures in an academic year. Suggested lecture topics are listed below.

2.2.5.1 Potential Lecture Topics

<u>The Big Picture:</u>

- Welcome to the CEO Program: Program Purpose, Overview, Schedule
- Starting Your Own Business: An Overview
- Entrepreneurial Testimony: My Experiences in Starting My Own Company *(Ideally, there would be two or three of these testimonial-type lectures throughout the year to provide insight and motivation).*
- Career Options: Entrepreneuring vs. Intrapreneuring

New Product Development:

- Brainstorming: A Customer-Driven Approach
- Innovation: Why Some New Products Succeed and Others Fail
- Product Screening: How to Evaluate New Product Concepts *(may require 2 lectures)*
- Product Development: Historical and Current Trends
- Locating Start-up Funding / Venture Capital

Business and Legal Issues:

- Creating a Business Plan
- Researching Potential Markets
- Product Liability
- Ethics

Product Protection and Marketing:

- Conducting Patent Searches
- Intellectual Property Protection: Patents
- Intellectual Property Protection: Copyrights
- Marketing 1: An Introduction
- Marketing 2: Product-specific Strategies
- Marketing 3: The Internet

International Issues:

- The Overseas Market: Broadening Your Perspective
- The Overseas Competition and Product Protection
- Taking Your Product Overseas *(Would our product sell overseas? How do I get it there? Risks and rewards.)*

Miscellaneous:

- "Outside the Box:" Innovative Thinking
- Rapid Prototyping: An Introduction
  (Such a lecture could inform the students of the existence and capabilities of rapid prototyping technology).

- Teamwork *(may require 2 lectures)*
  (Communication, Interpersonal Conflict Resolution, Characteristics of Successful Teams)
- Governmental Resources for Start-ups and Small Businesses

2.2.5.2 Potential Speakers

Lecturers will be recruited from throughout the University, the Virginia Tech Corporate Research Center (CRC), and industry. In general, speakers should be recruited for lectures in which they have significant interest and expertise.

The University is one potentially excellent source of lecturers. Many faculty members are uniquely qualified and enthusiastic about particular aspects of entrepreneurship, new product development and small business. Given the opportunity, individuals from various departments may gladly provide lectures once a year to CEO students.

Another potentially rich source of lecturers is the CRC. The Center includes many University-affiliated, high-tech start-up companies, as well as venture capitalists. These individuals have strong ties to Virginia Tech; many of them may be willing to provide occasional lectures for the CEO Program.

Finally, lecturers from industry should be recruited. These individuals can bring "real-world" perspective and motivation to the Program. Additionally, such interaction should benefit the company involved as well as the University and its students, by providing opportunities for networking, exposure, and communication.

2.2.5.3 Recruiting

In order to recruit lecturers, the CEO Program Advisor could send out targeted letters to faculty members throughout the University, Virginia Tech Corporate Research Center personnel, and industrial contacts with prior University interaction. These letters should include an overall description of the Program, a list of suggested lecture topics, and an invitation for involvement as a lecturer. Potential lecturers would be encouraged to select one of the recommended topics or suggest one of their own. In this way, the CEO Program could recruit qualified, enthusiastic lecturers to stimulate learning in student participants.

Realistically, recruitment of lecturers for the first year will involve considerable effort. However, many speakers will likely enjoy the opportunity to return each year; therefore, the effort required to organize the lecture series should decrease significantly after the first year.

2.2.5.4 Lecture Administration

Lectures should be given once a week and be mandatory for CEO students. One attractive arrangement would be to use a Tuesday/Thursday class schedule to allow 75 minutes per class. This would provide the lecturer with 45 minutes to 1 hour for the main portion of the lecture, followed by 10 to 15 minutes for student questions. Such an arrangement seems preferable to a Monday/Wednesday/Friday class schedule, which provides only 50 minutes of total class time. Assuming the Tuesday/Thursday class schedule is used, one class each week could be used for the lecture and the other used for Program administration and team meetings.

Section 2.2.6.3 incorporates these lectures in a suggested detailed Program calendar.

2.2.6 Additional Course Considerations

2.2.6.1 Course Credit

Although the CEO Program is a non-traditional student-involvement program, students will receive traditional course credit for their involvement. Currently, engineering students who participate in existing student-involvement programs in the Virginia Tech Engineering Department sign up for those programs as technical electives, independent study or senior design courses. Freshmen general engineering students receive credit within their "Introduction to Engineering" course for their (part-time) participation in these programs. Non-engineering students also participate, and are given credit for taking an engineering elective (though non-technical). I suggest that the CEO Program should handle course credit in similar fashion.

2.2.6.2 Student Evaluation

Students who participate for credit in a student-involvement program must be evaluated and given a grade each semester. The evaluation of students should not only *measure* gains in student learning; it should also *motivate* the students to learn. Awareness of the evaluation criteria will stimulate students to utilize their time effectively to ensure that they receive a satisfactory grade. The desire for a good grade should not be the only factor which motivates students; nevertheless, it is a strong motivating factor that can (and must) be harnessed effectively to produce student learning.

The CEO Program will involve multiple teams of students, each of which will work on the development of unique intellectual properties at a team- and product-dependent pace. Therefore, it is difficult to establish evaluation criteria that should apply to all students and all teams every year. Nevertheless, there are many common criteria that apply across the board to all students. Students must demonstrate their contribution to the accomplishment of team objectives, work well with others, communicate clearly with team members and others, and devote an appropriate amount of time and energy to the development of their product.

In addition to these general criteria, each team (and the individual members thereof) will be evaluated against the objectives it sets for itself at the beginning of the year. These objectives must be approved by the CEO Program Evaluation Team and by the faculty Advisor(s) before the team may commence working on their product. It is important that these objectives be clear and measurable, as they will be used as evaluation criteria for each team and its members. It will be the responsibility of the faculty Advisors and the Evaluation Team to work with each team to clarify and refine their objectives so that they may be used for meaningful evaluation.

One suggestion that comes from a conversation with Dr. Larry Mitchell, advisor to the Formula Car Team, is that specific, short-term deadlines can provide a useful and practical means of evaluation and motivation [88]. In line with his recommendations, I suggest the use of monthly deadlines for each CEO team. Each month, every team should submit a brief, informative report summarizing their activities for the current month, as well as laying out goals for the next month. This report should be a flexible document, varying greatly from team to team, product to product, and month to month. For example, one report could be a summary of the results of a preliminary patent search, while another could report a literature review of strategies for marketing home exercise equipment. The key element in each report must be a summary of the work done that month, broken down team member by team member, and a brief explanation of the work to be done in the coming month(s).

In addition to monthly progress reports, each team should also be required to present their progress periodically to the rest of the CEO participants. I suggest that brief (5 minute), informal "reports" be presented roughly twice a semester, in addition to a formal presentation at the end of each semester. The purpose of these oral presentations would be to develop communication skills in the students as well as to inform the Advisors and other participants about each team's progress.

At the conclusion of the year, each team should submit a final report, summarizing their work for that year and outlining the current stage in the development of their product. They should also include a game plan for future work on the product. This should be detailed enough to enable a team in the following year to continue the development of the product.

Another component of the final work to be submitted at the end of the academic year is a product prototype or "proof of concept." This will ensure that students get experience in product realization; it will also facilitate the prosecution of the patent application.

At the end of each semester, all student participants should submit peer evaluations. These would allow students to comment on the behavior, contribution, and people skills of their teammates. The purpose of these evaluations would be to empower students with a means by which they can reward (or punish) fellow students for actions generally unknown to faculty Advisors. The accountability provided by these evaluations should curb potentially irresponsible behavior on the part of the "bad eggs" and encourage responsible behavior on the part of the majority of students.

2.2.6.3 Program Schedule

In order to demonstrate the feasibility of the CEO Program, I have outlined one possible Program schedule below (Tables 3 and 4). This schedule is not intended for adoption "as is" by the CEO Program. Rather, it is provided as a starting point for the consideration of those who will actually implement the CEO Program.

The lecture series has been designed to educate students in the many areas necessary to become successful innovators and entrepreneurs. Therefore, the majority of lecture topics have been selected and arranged to provide the students with timely insights to assist them in subsequent phases of the product development process. In addition to this core set of "educational" topics, several supplemental lectures have been interspersed to motivate the students and broaden their horizons.

During the first semester, CEO students will generate product concepts, form teams, conduct preliminary market and patent research, formulate a "case" for their concepts, and present their product concepts to the Evaluation Team. As part of these presentations, each team must include specific objectives to be met by the end of the Spring Semester.

The team activities for the spring semester will be very team- and product-dependent. Therefore, I have left open the “Program Meeting” and “Team Activities” categories for most of the spring semester. It is assumed that each team will work toward accomplishing the objectives they specified at the end of the first semester. Since many of the products will be technologically intensive, much of the work during the second semester will probably involve detailed engineering design and development.

It is likely that some products will require more than one year for their development into market-ready intellectual property. Therefore, there may be some teams that do not create new product concepts, but rather continue the development of previous products. The schedule for these teams will be highly product-specific and has not been included below.

In addition to the “Team Activities” listed below, each team will be responsible to submit monthly progress reports. (For a discussion of these progress reports, please refer to Section 2.2.6.2).

Table 3. CEO Program Fall Semester Schedule

Wk	Program Meeting	Lecture Series	Team Activities
1	Welcome to the CEO Program: Overview and Schedule	“Brainstorming: A Customer-Driven Approach”	None
2	Ideation session (product category generation).	“Entrepreneurial Testimony” (1)	Team formation.
3	Ideation session (product category generation).	“Researching Potential Markets”	Team formation.
4	Work in teams (product concept generation/selection).	“Conducting Patent Searches”	Existing product / patent search.
5	Work in teams (product concept generation/selection).	“Outside the Box: Innovative Thinking”	Existing product / patent search.
6	Informal team presentations.	“Product Screening” (1)	Preliminary market research.
7	Informal team presentations.	“Product Screening” (2)	Preliminary market research / Building a case for the product.
8	Work in teams.	“Teamwork” (1)	Building a case for the product (market size, competitors, development costs, etc).
9	Work in teams.	“Creating a Business Plan”	Building a case (cont’d).
10	Work in teams.	“Marketing 1: An Introduction”	Laying out project-specific objectives.
11	Work in teams.	“Patenting Intellectual Property”	Laying out project-specific objectives.
12	Teams present their product concepts to Evaluation Team (oral and written reports).	*(No lecture)* Teams present their product concepts to Evaluation Team. (oral and written reports)	Presentation of product concepts to Evaluation Team.
13	Teams present their product concepts to Evaluation Team (oral and written reports).	“Starting Your Own Business: An Overview”	Presentation of product concepts to Evaluation Team.
14	Refining product development objectives / market research.	“The Overseas Market: Broadening Your Perspective”	Prepare semester report.
15	Refining product development objectives / market research.	“Entrepreneurial Testimony” (2)	Submit semester report.

Table 4. CEO Program Spring Semester Schedule

Wk	Program Meeting	Lecture Series	Team Activities
1	Work in teams.	"Innovation: Why some new products succeed and others fail"	Product-specific work.
2	" " "	"The Overseas Competition and Product Protection"	" " "
3	" " "	"Marketing 2: Product-specific Strategies"	" " "
4	" " "	"Product Liability"	" " "
5	" " "	"Teamwork" (2)	" " "
6	Informal team presentations.	"Product Development: Historical and Current Trends"	" " " (prototyping)
7	Informal team presentations.	"Entrepreneurial Testimony" (3)	" " " (prototyping)
8	" " "	"Locating Start-up Funding / Venture Capital"	" " " (prototyping)
9	" " "	"Rapid Prototyping: An Introduction"	" " " (prototyping)
10	" " "	"Marketing 3: The Internet"	" " " (prototyping)
11	" " "	"Copyrighting Intellectual Property"	" " " (prototyping)
12	" " "	"Governmental Resources for Start-ups and Small Businesses"	Prepare presentation and final report.
13	" " "	"Taking Your Product Overseas"	Prepare presentation and final report.
14	Final Presentations	"Career Options: Entrepreneurship vs. Intrapreneurship"	Prepare presentation and final report.
15	Final Presentations	*(No lecture)* Final Presentations.	Submit final report and prototype.

2.3 Distinguishing Features of the CEO Program

The CEO Program is a unique student-involvement program concept. Student participants will learn entrepreneurship as they develop and market intellectual property. As those properties are commercialized, the revenues generated are intended to defray at least some of the costs associated with running and enhancing the CEO Program. A portion of these revenues will be shared with the student participants who worked to invent and develop those properties. The CEO Program should provide a unique environment in which students from many majors and various academic levels work together to generate intellectual property.

2.3.1 Educate Through Intellectual Property Generation

One of the most distinguishing features of the CEO Program is its intention to engage students in the generation of intellectual property. Student participants will learn innovation, product development, and entrepreneurship skills as they are directly involved in the development and commercialization of intellectual property.

2.3.2 Revenue Generation

The CEO Program is intended to provide some revenue for the University after some initial startup period. As the Program gets underway, revenue resulting from the successful commercialization of intellectual properties can be directed to those departments that commit some level of resources (human, financial, etc) to the CEO Program. Once the CEO Program has been in operation long enough to attract a substantial number of student participants and is generating a significant amount of revenue, it *may* be feasible for the Program to become a completely independent entity (Center). It is hoped that the CEO Program may someday be able to "pull its own weight" financially as intellectual properties are successfully commercialized. Whether or not it is able to become financially self-sufficient at some point in the future, it is reasonable to assume that the CEO Program will generate some revenue for the University and defray at least part of the expenses related to its operation and development.

2.3.3 Students Share Profits

One of the distinguishing features of the CEO Program is that students can benefit financially from their participation. Federal law and institutional policy allow for the sharing of profits by the inventors of an intellectual property. In that sense, any individual has the freedom to patent a concept and receive royalties from the profits it generates. In general, however, ignorance of the patenting process, a lack of financial resources, and other factors effectively deter most students from attempting to patent any of their creative ideas. The CEO Program is designed to provide students with an environment in which they can learn about the product development process, develop business and engineering acumen, and actually patent and market their own product concepts. Students who work on the development of a patent will share in the net revenues received from its commercialization. The potential to benefit financially should prove to be an incentive for participation in the CEO Program.

2.3.4 Cross-Disciplinary, Multi-Year Entrepreneurship Program

Educators have long been aware of the benefits of an educational environment involving students from various majors and academic levels. In spite of this awareness, there remains a conspicuous dearth of cross-disciplinary, multi-year student-involvement programs, particularly in the area of entrepreneurship.

There is an abundance of universities nationwide offering *courses* in entrepreneurship; however, very few universities offer *programs* in which students can learn entrepreneurship by actually developing real products that will be sold to real customers. Though extremely few in number, such programs do exist, a smaller number of which also incorporate students from various majors and/or academic levels. (For a description of those programs, please refer to Section 1.5). Such programs are still the distinct exception rather than the rule. Likewise, the CEO Program will stand out in providing an environment in which cross-disciplinary student teams learn entrepreneurship over the course of their academic careers by engaging in the development of real intellectual properties.

Chapter 3

Remaining Challenges

Before the CEO Program can be successfully implemented, there are several sizeable hurdles to be overcome. Probably the most formidable challenge to CEO Program implementation is presented by attitudes and beliefs inherent in academic culture itself. Once the academic community becomes convinced of the value of the CEO Program, however, there remain several more challenges. It will be necessary to outline the details of the Program to demonstrate its feasibility. Some University resources must be made available. In order to provide the impetus necessary to launch the CEO Program, seed funding will be required. Additionally, it will be necessary to nurture creativity in students. A Program Advocate must be found who will overcome these obstacles and effect the implementation of the CEO Program. A final, longer-term challenge will be to expand the CEO Program to include business entry education as well as innovation and product development.

3.1 Academic Culture

Today's academic culture, comprised of time-honored assumptions, values, and practices, may (initially) find fault with several fundamental aspects of the CEO Program concept. In particular, it may be difficult to convince some faculty members and department heads of the educational and scholarly value of a student-involvement program that exists to generate intellectual property. They may feel that a profit motive adulterates the university's commitments to education and research. Some may find it difficult to believe that innovation can be taught or learned. Faculty members may not see participation in the CEO Program as of tangible value to them personally. Finally, some may think it unlikely that teams of undergraduate students can really be expected to develop new, profitable intellectual properties.

Therefore, perhaps the most significant challenge set before the CEO Program is to encourage the changes in attitudes and beliefs necessary to generate interest and enthusiasm among the academic community. If department heads and individual faculty members are not convinced of the validity of CEO Program assumptions and the value of its goals, the CEO Program cannot hope for realization. On the other hand, if key University personnel enthusiastically endorse the CEO Program concept, its implementation may lie just around the corner.

3.2 Program Feasibility

In order for the CEO Program to be implemented, a workable formulation of the concept must be developed. This thesis is, in large part, an attempt to demonstrate the feasibility of one realization of the CEO Program concept. Chapter 4 addresses the feasibility of the Program in more detail.

3.3 University Resources

The CEO Program will require the use of University resources in order to succeed. These can be separated into two categories: human resources and physical resources.

<u>Human Resources</u>: Student teams will require guidance and input from faculty mentors. As the Program gets underway, the total number of participating students will likely be few. Therefore, the Program Advisor(s) may be able to act as mentors to all student teams. However, as the Program grows, there will be a need for additional faculty members to serve as student team mentors. Departments should recognize faculty mentoring as a valuable form of involvement with students, despite its somewhat nontraditional nature. Likewise, the faculty members themselves should see participation as a privilege rather than a duty; therefore, they must come to view it as a valuable, personally rewarding investment of their time and energy. Convincing departments and individual faculty members of the value of the CEO Program will be the responsibility of the Program Advocate discussed below.

<u>Physical Resources</u>: Many CEO Program activities will not require dedicated University resources. Program-wide meetings, as well as lectures, can be scheduled weekly to take place in University classrooms. Nevertheless, the CEO Program will require some dedicated physical resources. Specifically, it will require a dedicated workspace and the resources (computers,

telephones, prototyping facilities, etc.) necessary to maximize the productivity of student participants.

Dedicated physical resources speak volumes to students about the commitment of the University to the CEO Program and to them as participants. It indicates a sense of permanence and importance, and it invites their participation. Dedicated physical resources can serve to improve student motivation, morale, and the sense of ownership critical to the success of the CEO Program.

Initially, when the number of student participants is small, it could be argued that the need for dedicated resources would be minimal. After all, students *could* work in existing computer labs and student lounges as they develop their products. However, this would not be an ideal situation. As mentioned above, the existence of dedicated physical resources lend a sense of permanence, importance, and ownership to the Program, thus facilitating the recruitment and retention of student participants. Therefore, as the Program seeks to recruit new participants during the first few years of its existence, dedicated physical resources could be a real selling point. Besides these significant motivational factors, dedicated resources should also enhance the productivity of student teams and provide them with the best possible environment for success. As the Program grows, the need for dedicated physical resources will become even more pronounced.

3.4 Seed Funding

In order to adequately educate student participants and develop marketable intellectual properties, the CEO Program must have access to discretionary funds. These funds will be used for everything from the purchase of computers and office supplies to the development of new product prototypes. Though the CEO Program is intended to generate revenue for the University after a few years of operation, and *may* even be able to become fully self-supporting at some point in the future, seed funding will be required initially.

Seed funding for the CEO Program could come from many sources. There are governmental and state agencies that regularly contribute to new educational programs. There are also several foundations, programs, and organizations nationwide that exist to promote entrepreneurial education and endeavors. Organizations of this type have provided generous funding to several entrepreneurial education programs throughout the nation. Finally, philanthropic individuals, usually alumni, have given large contributions to help launch programs like these at some universities.

3.4.1 National Science Foundation

Perhaps the most logical source of start-up funding is the National Science Foundation (NSF). "The NSF is an independent U.S. government agency responsible for promoting science and engineering through programs that invest ... in ... research and education projects in science and engineering [89]." "Its investments in research and education aim to build and strengthen a national capacity for innovation that can lead over time to the creation of new shared wealth and a better quality of life [90]." The stated goals and missions of the NSF are similar to the envisioned outcomes of the CEO Program. In fact, through the Southeastern University and College Coalition for Engineering Education (SUCCEED), the NSF partly funds the "Engineering Entrepreneurs Program" at North Carolina State University [63, 64]. Of any educational effort nationwide, this Program bears the most similarities to the CEO Program concept. Therefore, the NSF may indeed be an excellent source of potential seed funding.

a. NSF *Course and Curriculum Development (CCD) Program*

Among the many NSF programs, one seems particularly well suited to the CEO Program concept. The Undergraduate Course and Curriculum Development (CCD) program was created "to **improve the quality of undergraduate courses and curricula in** science, mathematics, **engineering**, and technology [91, p. 1]." The priorities of the CCD program are two-fold:

1) ***to promote the development of multidisciplinary and interdisciplinary courses that will better prepare students for the science- and technology-based environment of the future****; and*
2) *to encourage SME&T faculty to take leadership roles in developing educational experiences that enhance the competence of prospective teachers and encourage students to pursue teaching careers (emphasis added)* [91, p. 2].

The CCD program supports projects that meet only one of these priorities, in addition to projects addressing both priorities. "Several CCD awards in FY 96 were made to support projects that promote the development of multidisciplinary or interdisciplinary courses and curricula [91, p. 2].” Therefore, it seems that the Course and Curriculum Development program is an excellent potential source of CEO Program start-up funding.

b. NSF *Design, Manufacture and Industrial Innovation Program*

“The Learning Factory,” comprised of curriculum reform efforts plus physical facilities, is a collaboration between Penn State, the University of Washington, the University of Puerto Rico, and the Department of Energy/Sandia National Laboratories [68]. Its intent is “to provide an improved educational experience that emphasizes the interdependency of manufacturing and design in a business environment [68].” This project was supported by the NSF’s Design, Manufacture and Industrial Innovation program area, under the jurisdiction of the Directorate for Engineering. The NSF Program name is “Materials Processing and Manufacturing.” This project, funded for $2.7M, was funded from July 1994 through June 1997 [NSF project number #9413880].

It is likely that there are several other NSF programs for which the CEO Program would be a competitive candidate for funding. Based on published information alone, it is difficult to determine the suitability of the CEO Program to the multitude of NSF programs. Therefore, I recommend that the person(s) who implements the CEO Program should contact NSF directly to determine which program would be the best match. Specifically, it may be beneficial to contact the directors of the following departments: the Directorate for Engineering, the Directorate for Education and Human Resources, the Office of Cross-Disciplinary Activities, and the Office of Multi-Disciplinary Activities.

3.4.2 Virginia Center for Innovative Technology

Another possible source of seed funding is the Virginia Center for Innovative Technology (CIT). A nonprofit organization of the state of Virginia, CIT is mandated to promote the economic development of the state of Virginia by assisting new ventures and educational efforts likely to result in the creation of wealth and jobs for Virginians. Specifically, one of CIT’s goals is to “enhance and expand the R&D capabilities of Virginia's colleges and universities, including transferring technological advances to the private sector [92].”

The CEO Program, intended to generate new (often technologically intensive) intellectual properties, has the potential to generate wealth and spin-off companies in Virginia. CIT may consider the CEO Program a good investment in the future of Virginia, and thus be willing to supply some seed funding. However, in order to attract CIT funds, it will be necessary to partner with industry on specific endeavors and to demonstrate the potential for economic impact within a few years. Therefore, CIT may become more interested in the CEO Program after it has been able to generate potentially profitable intellectual properties or spin-off companies.

3.4.3 Entrepreneurial Foundations, Programs, and Organizations

Nationwide, there is a growing number of organizations, programs, and foundations dedicated to entrepreneurship in some fashion. Many of these were formed as networks of entrepreneurial individuals, companies, societies, and centers seeking to promote entrepreneurial endeavors. A few such organizations also provide funding to promising entrepreneurial education programs.

a. <u>The Lemelson National Program in Invention, Innovation, and Creativity</u>

An entrepreneurial course at the University of Nevada at Reno enjoys the use of the Lemelson Center for Invention, Innovation, and Entrepreneurship. This center was funded generously by the Lemelson Foundation, through its National Program. Samuel Lemelson, who passed away October 1, 1997, was one of most prolific inventors of all time, holding 500 patents throughout his career. Samuel Lemelson, with his wife Dorothy, established a foundation for the promotion of invention and innovation in America's young people. As part of its efforts, the Lemelson Foundation created the National Program in Invention, Innovation, and Creativity to promote educational efforts along these lines. Therefore, this may be another avenue for start-up funding for the CEO Program.

National Collegiate Inventors & Innovators Alliance
Lemelson National Program
Hampshire College-LM
Amherst, MA 01002-5001
Tel: (413) 582-5318 ... Fax: (413) 582-5834
Email: nciia@hampshire.edu
Web Site: http://hamp.hampshire.edu/nciia/

b. <u>The Ewing Marion Kauffman Foundation: Center for Entrepreneurial Leadership, Inc.</u>

"The Kauffman Foundation engages in operating programs and targeted grantmaking in our two areas of interest - entrepreneurship education and youth development. We are interested in supporting sustainable programs and projects that will lead to individual, organizational and community self-sufficiency." This foundation, boasting a billion-dollar endowment, offers many targeted, creative programs aimed at promoting entrepreneurship and the development of youth. Its particular interest in "*sustainable* programs and projects" may make the CEO Program a natural fit. However, the Kauffman Foundation does not take unsolicited grant proposals. Therefore, it may be instructive to contact the Foundation directly for more information about funding possibilities.

Grant Administrator
Ewing Marion Kauffman Foundation
4900 Oak
Kansas City, Missouri 64112-2776
(816) 932-1000
http://www.emkf.org/

c. <u>The Capital Network (TCN)</u>

Because it may become a revenue-generating entity at some point in the future, the CEO Program itself can be viewed as a potentially profitable entrepreneurial endeavor. Therefore, it may attract the attention of venture capitalists at some point in the future. Rather than pursuing individual venture capital companies, it may be more effective to contact a network of such firms. One such network is The Capital Network (TCN).

> *TCN, a non-profit economic development organization, was developed in response to a growing need to provide entrepreneurial ventures with training and access to investors. The Network offers investor-to-entrepreneur introduction services, educational programs, venture capital conferences, seminars, literature, software, and an extensive "know-how network" of experts and advisors* [93].

The mission of The Capital Network is "to promote economic growth matching promising ventures to potential investors, educating companies and investors on business financing issues, and linking emerging companies appropriate professional business expertise [93]."

Whether or not TCN is approached regarding seed funding, it may be beneficial to contact them for guest lecturers, general suggestions, and referrals.

The Capital Network
3925 West Braker Lane
Suite 406
Austin, Texas 78759
http://www.thecapitalnetwork.com

3.4.4 Philanthropic Individuals

One possible source of seed funding could be philanthropic entrepreneurs, most likely alumni. The Entrepreneurship Program at the University of Iowa, for example, received generous contributions by a prominent Iowa graduate, venture capitalist John Pappajohn. In fact, Pappajohn has funded Pappajohn Entrepreneurial Centers at five colleges in the state of Iowa for close to $5,000,000 [94]. Likewise, the Leonhard Center for Innovation and Enhancement of Engineering Education at Penn State was established by an endowment gift from William (Penn State, '36) and Willys Leonhard. This Leonhard Center has given birth to the Envisioneer™ Program, in which students work on innovative ways to improve engineering education [66]. While not suggesting that alumni contributions be actively pursued, it is one possible source of seed funding for the CEO Program.

3.5 Nurturing Student Creativity

As mentioned above, traditional high school and university environments often stifle innate creativity, demanding that students come to *the* correct solution to every problem. After several years' immersion in such a stultifying climate, it may be difficult for some students to be willing to generate and stand behind their own original solutions to open-ended problems. Therefore, one of the significant challenges facing the CEO Program is to find ways to encourage creativity in students who have been conditioned to be imitators and not originators. Ideally, these efforts would take place in the context of a broader paradigm shift among educators to nurture creativity in students. Effecting such a paradigm shift is, of course, far outside the realm of this work. Nevertheless, the CEO Program must nurture creativity in its participants in order to be successful in teaching them to innovate and in order to generate marketable intellectual properties.

3.6 Program Advocate

The implementation of the CEO Program hinges upon the efforts of a Program Advocate, whose role includes the many challenging tasks mentioned above. Without the committed efforts of this individual, the CEO Program may never become a reality, regardless of its potential benefit to students, to the University or to society at large.

The first critical task to be tackled by the Advocate is to address the academic culture issues mentioned previously. The Advocate will play a central role in convincing key University personnel of the value and feasibility of the CEO Program concept.

Another critical task will be the procurement of University physical resources. Dedicated University resources (as listed above) will help "sell" the Program, giving it a feel of permanence and importance. Besides these benefits, such resources will maximize the productivity of student participants.

The third task to be addressed will be to secure start-up funding. As has been previously mentioned, the CEO Program is intended to generate some level of revenue for the University as intellectual properties are successfully commercialized. However, it will be necessary to have some funds available to get the Program off the ground. It will be the Advocate's responsibility to secure that short-term funding.

Though it is listed here as the third task, it may be advantageous to secure start-up funding first. The availability of significant start-up funding could help convince the University community of the value of the Program. This, in turn, could motivate the commitment of University physical and human resources.

3.7 Business Entry Component

The CEO Program concept, as presented in this thesis, has focused primarily on teaching innovation in the context of the generation of intellectual properties. This can be considered as one side to the entrepreneurial coin. The other, equally important side to this coin is business entry. A well-rounded entrepreneurship education program should include both innovative product creation *and* small business startup and management. Ideally, the goal of the CEO Program would be to graduate students who are equipped to create their own products *and* start their own companies.

One of the long-term challenges to the CEO Program is, therefore, to develop the business-entry component to the Program. This may involve offering courses that teach business creation and management to CEO Program participants. The University must determine whether this is best done as a set of undergraduate electives, as a concentration or minor, or as a separate graduate program.

3.8 Conclusion

In order for the CEO Program to be successful, there are several barriers to be overcome. The University community must perceive the value of the CEO Program. Departments must be willing to commit human and physical resources. Individual faculty members, in turn, must see involvement not as a duty but as a privilege. In order to launch the CEO Program, seed funding must be obtained. In addition to these challenges, the CEO Program must encourage creativity in students who have been conditioned otherwise.

Surmounting each of these hurdles will be the challenging job of the Program Advocate. The Advocate will also be responsible for recruiting guest lecturers, faculty participants, and the student participants themselves. With such a laundry list of challenging tasks, it is essential that the person who steps forward to assume the role of Advocate be committed to the implementation of the CEO Program. Additionally it will be necessary for the Advocate's department to recognize the potential value of the CEO Program and provide him/her with the freedom to aggressively pursue its implementation.

Farther down the road, the CEO Program should expand to include business entry. Participants should be taught not only how to create innovative products but also how to start and manage their own innovative small businesses.

Chapter 4

Evaluation and Conclusion

The CEO Program has been proposed as one way to equip students for the marketplace of the future. The following is an evaluation of the potential value of the CEO Program, as well as suggestions about actually measuring the impact of the Program after it has been implemented. The feasibility of the CEO Program is also evaluated. Remaining challenges and unanswered questions are discussed. Finally, I recommend that the CEO Program be implemented, identifying the significant obstacles that must be overcome in order for the CEO Program to be a success.

4.1 *Expected* Program Value

One of the primary missions of the university is to develop students into productive, responsible members of their professions and of society by imparting to them essential skills and knowledge. Parallel university missions include conducting research, supporting the public interest, and fostering regional economic development. To the degree that the CEO Program helps the university accomplish these goals, it can be said to have value for students and for the university.

4.1.1 Development of Student Skills

As mentioned previously in the discussion of key educational literature, there is a growing realization of the need to focus on the development of students as emerging professionals [49, 50], by giving particular attention to gains in specific ***skills*** [51, 49, 52, 55, 56]. The Accreditation Board for Engineering and Technology (ABET) has provided an excellent summary of critical skills in *Criteria 2000* [56]:

Engineering programs *must demonstrate that their graduates have*

(a) an *ability* to apply knowledge of mathematics, science, and engineering
(b) an *ability* to design and conduct experiments, as well as to analyze and interpret data
(c) an *ability* to design a system, component, or process to meet desired needs
(d) an *ability* to function on multi-disciplinary teams
(e) an *ability* to identify, formulate, and solve engineering problems
(f) an *understanding* of professional and ethical responsibility
(g) an *ability* to communicate effectively
(h) the broad *education* necessary to understand the impact of engineering solutions in a global and societal context
(i) a *recognition* of the need for, and ability to engage in life-long learning
(j) a *knowledge* of contemporary issues
(k) an *ability* to use the techniques, skills, and modern engineering tools necessary for engineering practice.

* *Italics added for emphasis.*

The CEO Program, as envisioned by the author and outlined in the preceding chapters, has been designed to be effective in developing these skills in participating students. All student participants will be given the opportunity to work in multi-disciplinary teams (thus satisfying ABET criterion ‘d’ from above). They will work in these teams to identify and solve engineering problems (e). The purpose of their efforts will be to address contemporary issues in the greater societal and global contexts (j, h). Throughout the year, particularly in the lectures, they will learn about product liability and professional responsibility (f). They will make use of their knowledge of science and mathematics as well as many engineering tools and techniques (a, k). Depending on the project, students may also have opportunity to conduct experiments or design specific components, processes, and systems (b, c). Throughout the Program, students must be active about learning; therefore, this experience promises to instill an enthusiasm for life-long learning (i).

One area of potential concern, however, is in the realm of product realization. The Department of Mechanical Engineering at Virginia Tech strongly desires to provide every student with at least one experience in product realization. This Department is not alone in recognizing the value of product realization. The American Society of Mechanical Engineers (ASME) Council on Education issued a report in 1995 entitled *Integrating the Product Realization Process (PRP) into the Undergraduate Curriculum* [52]. The report argues strongly that product realization must be integrated into the undergraduate engineering curriculum. The Accreditation Board for Engineering and Technology (ABET) is somewhat less emphatic regarding product realization, per say, though the "Program Criteria for Mechanical . . . Engineering Programs" does state that *engineering design* must be included in "some integrated educational experience in the terminal portion of the program [78]."

The Department would like to ensure, therefore, that every Mechanical Engineering student be able to design, develop, and actually build a product. This is an area of potential concern for the CEO Program, since the potential exists for some participating seniors to graduate before their product is developed enough to be "prototype-able." It is hoped that the Program Advisors can ensure that Mechanical Engineering seniors work on products that can be prototyped before the end of the academic year.

In addition to the skills mentioned in *Criteria 2000*, the previous discussion about "*Market Trends and Implications*" included several implications for engineering education, in light of the trends now taking place in the world. I mentioned that students must grow in their awareness of the world. They must learn to thrive in an informationally intense, high-tech age. They must be committed to learning throughout their lifetime. Finally, they must learn to innovate.

The CEO Program should address each of these implications. Through the lecture series, student participants will be exposed to worldwide economic and political trends that may affect their businesses and lives. Many of the products they develop will be high-tech, information-intensive products. As was mentioned above, they will learn, through experience, the importance of life-long, active learning. And, at the very heart of the CEO Program, they will learn how to be more innovative.

Therefore, it is my opinion that the CEO Program has the potential to impart many of the skills identified by ABET and others as of paramount importance to future engineering professionals. It also has the potential to address many of the implications of the global and national socioeconomic trends currently reshaping the world. In this way, the CEO Program promises to be an effective educational program that prepares students to face the marketplace of the future.

4.1.2 Parallel University Missions

Along with the educational development of students, the university has several parallel missions: to conduct research, to support the public interest, and to foster regional economic development. The CEO Program may facilitate the accomplishment of these objectives. The purpose of the CEO Program is to develop students into professionals as they work together in teams to generate intellectual property. By generating intellectual property, the CEO Program can also help to support research activities by providing a vehicle for the application of research findings to industrial and societal issues. It could be argued that universities currently seek to develop and patent potentially marketable research findings. While this is true, it is likely that some faculty members have the seeds of new intellectual property in mind but lack the human resources necessary to bring those concepts to fruition. The CEO Program promises to provide some additional human resources.

Finally, the CEO Program has the potential to promote the economic interests of the region and the State of Virginia by the generation of wealth, spin-off businesses and jobs that may result from the successful commercialization of intellectual properties.

Therefore, I conclude that the CEO Program, as presented here, should have value for the University. It has the potential to develop critical skills in student participants, to support research efforts, and to promote the economic interests of the State and the Nation by the generation of wealth and jobs.

4.2 *True* Program Value

While a strong case has been made for the *expected* educational value of the Program, its *true* value can only be determined subsequent to its implementation. As per ABET's *Criteria 2000*, the outcomes of any educational endeavor must be assessed and the feedback used for the improvement of the program [56].

A model of intellectual and ethical development was developed by William G. Perry in the late 1960’s [95]. His model describes learning as a progression along a continuum (divided into nine stages) tracing development in three categories: reliance on authority, commitment to decisions, and view of vagaries in data. Over the years, the Perry Model has been widely accepted as a tool for the measurement of the intellectual and moral development of students.

Though Perry's original model was developed with the use of personal interviews, the costs associated with this method are often prohibitive, since it requires the involvement of highly paid professionals to evaluate those interviews. Subsequent researchers have sought to develop tests that measure the "Perry Level" of students in ways that require less effort and expense than extensive interviews. Knefelkamp and Widick developed a written (essay) test called the Measure of Intellectual Development (MID) [96]. William S. Moore, who participated in the development of MID, later went on to create a questionnaire version, the Learning Environment Preferences (LEP) [96]. More recently, Culver, Fitch, and Felder collaborated to develop a modified version of the LEP tailored to students in technical fields: the Technical Student Learning Environment Preference questionnaire (TSLEP) [96].

A questionnaire-based evaluation, such as TSLEP, could be used as a method for evaluating the effect of the CEO Program on participating students. In order for such an evaluation to be successful, however, it should be done in concert with a larger evaluation effort. This will allow for comparison with various control groups in order to determine the level of effectiveness of the CEO Program. It is important to evaluate freshmen in order to provide a baseline for comparisons; the scores of engineering students who do not participate in the CEO Program will also be needed to evaluate the effectiveness of the Program.

Measuring the Perry Level of CEO Program participants will provide an excellent source of feedback regarding the general intellectual and ethical development of the students. However, it would also be beneficial to measure the effectiveness of the CEO Program in more entrepreneurship-specific terms.

Evaluating the effectiveness of an entrepreneurial program is a daunting task. Upton, *et al.*, suggest several reasons for the lack of accepted, adequate measures for the long-term effectiveness of entrepreneurship education. Among the reasons cited are the difficulty in defining what is meant by entrepreneurship, the relatively recent appearance of entrepreneurial courses, and the lack of agreement over exactly what constitutes a "successful" program [97].

Block and Stumpf present criteria for the evaluation of entrepreneurship education effectiveness, suggesting specific criteria for each stage in the life cycle of the course [98].

These criteria range from "number of students enrolled" and "self-perception of learning and capability" (for students currently taking the courses) to "contribution to society and economy" and "firm performance" (for those who took it more than 10 years ago) [98, p. 21]. They also recommend several questions for use in assessing entrepreneurial education effectiveness [98, p. 25].

4.2.1 Suggested Future CEO Alumni Survey

While there is little consensus in the literature on the best metrics of success, one common theme is that alumni feedback is central to the evaluation of an entrepreneurship course or program. In fact, Vesper, reporting the results of a faculty survey, indicated that "alumni comments years later" was listed as the *most significant criteria of entrepreneurial course quality* [99]. Therefore, I have composed a survey to be distributed to CEO Program alumni (say 3 to 10 years after graduation). It has been based, in part, on observations made from previous entrepreneurial alumni surveys [98-100]. It is provided as a starting point for future development of a CEO Program alumni survey.

In soliciting feedback from CEO Program alumni, two areas are of particular interest: alumni perceptions of course effectiveness, and the measurable impact of the course(s) on their careers. The collection of alumni perceptions of CEO Program effectiveness should provide Program administrators with a valuable resource for the improvement of the Program. The impact of the CEO Program on alumni careers will be measured by gathering data regarding measurable entrepreneurial activities: business startups, management of new ventures, patents, and so forth. This information should be helpful in quantifying the impact of the CEO Program on the careers of its participants.

The survey is designed to gather information in three main categories: occupational history and current job status, perceptions of CEO Program effectiveness, and entrepreneurial experiences. The survey has been included in Appendix D.

4.3 Program Feasibility

The CEO Program has been shown to be potentially valuable, and suggestions have been made regarding its future evaluation and improvement. However, before the University can seriously consider adopting this Program, the feasibility of its implementation and operation must be considered. Several questions arise when considering the feasibility of the CEO Program concept.

Are students capable of developing useful, marketable, intellectual properties?

The success of the CEO Program hinges, in large measure, on the degree to which students are able to develop useful, marketable intellectual properties. I concede the improbability that students, left to themselves with no assistance, will be able to develop marketable intellectual properties. However, *provided with encouragement, education and regular guidance*, I submit that students *are* capable of the creativity and hard work necessary to develop new, marketable intellectual properties.

Existing entrepreneurial programs at other universities have demonstrated that students are capable of creating products and even starting companies. In the John Pappajohn Entrepreneurial Center programs at the University of Iowa, students have started at least two companies [101]. Students in a one-semester senior-level entrepreneurship course at the University of Nevada at Reno develop product prototypes as part of the course. Some of these products have made it all the way to market or are currently being pursued in that direction [69]. Entrepreneurship majors at Baylor University are encouraged to start their own companies. Their web site indicates 10 student-run companies and 7 successful alumni businesses [102]. Therefore, it seems reasonable to assert that students in the CEO Program will be able to create marketable intellectual properties, provided that they are given regular encouragement, guidance, and education.

Second, the students' lack of experience should not count against them, since there must be a first time for everything. The most experienced entrepreneurs and innovators were not born with their knowledge and skills. They had to learn those things at some point. University students, with their enthusiasm and potential for creativity, are in an ideal position to learn how to develop innovative intellectual properties.

Are the necessary resources available to the Program?

In order for the CEO Program to be successful, several resources must be available. These include human resources, facilities, and seed funding, as discussed in Chapter 3.

Human resources: The CEO Program will require several types of human resource, including a Program Advocate, Program Advisor(s), and team mentors.

The Program Advisor must be an individual who is committed to the CEO Program concept. The Advocate's responsibilities will include convincing the University of the value and feasibility of the Program, securing start-up funding, and recruiting student and faculty participants. Additionally, it would be logical for the Program Advocate to become the Advisor for at least the first year of the Program.

In general, the feasibility of finding an individual willing to commit time and energy to a new, nontraditional educational program would be low. However, in this case, such an individual already exists and has been quite involved in the development of the CEO Program concept. Dr. Charles F. Reinholtz, the W.S. White chair of Mechanical Engineering at Virginia Tech, is an excellent candidate for CEO Program Advocate.

Once the Program has been implemented, it will require the oversight of a Program Advisor(s). Ideally, there would be two such Advisors, one from the College of Engineering and one from the College of Business. Initially, however, when the total number of student participants is small, one Advisor may suffice. The Advisors will provide oversight and administration to the Program and serve as student team mentor(s) for the first year or two (until additional faculty members become involved as team mentors).

It seems reasonable that a professor in the College of Business can be found who would enjoy the opportunity to participate in the CEO Program as Advisor. Nevertheless, at this point, it is difficult to determine how easily a business faculty member could be recruited to serve as an Advisor.

In addition to Program Advisors, some faculty members must be available to serve as student team mentors. These mentors will provide technical (and business) perspective and accountability to the student teams. Additionally, some faculty members may elect to suggest their own intellectual property concepts and recruit a student team(s) to assist in the development of those concepts.

Provided that faculty members see involvement with the student teams as valuable (to them personally as well as to the students) and if they receive departmental recognition for their involvement, then it seems likely that mentor recruitment will not be overly difficult. Once again, the brunt of the responsibility falls on the shoulders of the Program Advocate to communicate to the University the value and feasibility of the CEO Program.

Facilities: In order for the CEO Program to succeed, it will require access to some University facilities, as was mentioned in the previous chapter. Once again, assuming that the University sees the value of the CEO Program, it is reasonable to assume that resources will be made available.

Seed Funding: The CEO Program, unlike most educational endeavors, is intended to generate revenue, possibly even becoming financially self-supporting at some point in the future (though this has yet to be demonstrated). Initially, however, seed funding will be required. This will serve as the discretionary funds necessary to develop the first few generations of intellectual properties. Hopefully, in time, some of these properties will produce enough revenue to support, at least in part, future operation and development of the CEO Program.

Aside from facilitating the development of intellectual properties, seed funding will also serve another important purpose. It will help convince the University of the value of the Program. Namely, securing a significant amount of start-up funding communicates that someone beyond the walls of the University thinks that the CEO Program is worthy of implementation. In this way, start-up funding may indirectly facilitate the recruitment of faculty participants and the procurement of dedicated University facilities. Therefore, seed funding will be essential to the successful implementation of the CEO Program.

There are many possible sources of this seed funding. These possibilities include the NSF, Virginia's Center for Innovative Technology (CIT), any one of several national entrepreneurial societies and networks, and philanthropic individuals. The abundance of potential sources of seed funding bodes well for the CEO Program. It is reasonable to assume that at least one of these organizations or individuals will enthusiastically embrace the CEO Program as worthwhile and provide the start-up funding it requires.

Will the existing arrangements with Virginia Tech Intellectual Properties, Inc. (VTIP) be appropriate for the CEO Program?

Intellectual properties generated at Virginia Tech are protected and commercialized in conjunction with Virginia Tech Intellectual Properties, Inc. (VTIP). The arrangements that exist between the University and VTIP are intended to support the commercialization of intellectual properties generated in the course of *traditional research activities* [see Appendix A]. Though the CEO Program will be a new, somewhat nontraditional program, the existing arrangements appear to be suitable for the protection and commercialization of CEO-generated intellectual properties.

If successful, the CEO Program could become a large entity, generating many intellectual properties each year. It is, therefore, possible that the CEO Program may require a disproportionate percentage of VTIP resources (particularly human resources). At that point, it may be necessary to renegotiate a more suitable arrangement between the CEO Program and VTIP. However, that point is certainly a long way down the road. In the mean time, I recommend that the CEO Program protect and commercialize their intellectual properties according to existing University-VTIP arrangements.

4.4 Unanswered Questions

As demonstrated above, the CEO Program appears to be a worthwhile educational endeavor. Furthermore, its implementation and operation appear feasible. However, there remain several unanswered, and therefore potentially troubling, questions.

Is it likely that the Program will generate enough intellectual properties to ensure the revenue levels required to sustain CEO Program operation?

It has been suggested that, at some point in the future, the CEO Program *may* be able to generate enough revenue to become a financially self-supporting entity. This could occur as a result of one enormously successful intellectual property product or a sizable number of moderately successful products.

However, demonstrating when or even if this will occur is very difficult at this time. Many details of the CEO Program are presently unknown: the number of Program participants, the resources it will require (meeting space, prototyping costs), and so forth.

Besides the unknown nature of the Program itself, the profitability of intellectual properties varies greatly. Some intellectual properties are immensely profitable. Gatorade™, for example, has been a veritable cash cow for the University of Florida, generating millions of dollars in royalty revenues. On the other hand, other intellectual properties never generate enough revenue to cover their own development, let alone generate a profit. Between these extremes are properties that do generate some profits for the university and for the inventors. Exactly where most CEO-generated intellectual properties will fall in this wide spectrum is unknown at this point.

For these reasons, it is very difficult to predict whether or not the CEO Program will generate enough profit to support itself.

Will people support the CEO Program concept? Will they view it as a worthwhile endeavor?

This is perhaps the greatest challenge awaiting the Program. Without the support of many individuals, departments, and organizations (both within and without the University), the CEO Program cannot hope to succeed. However, if this innovative educational concept can capture imaginations and garner enthusiastic support on many fronts, its implementation seems very likely to occur.

After considering the CEO Program for many months, I do believe that it has potential to become a successful program; that it is valuable and feasible; and that it should, therefore, be implemented. Whether others will come to share this view can only be seen in time.

4.5 Conclusion

Global socioeconomic forces are reshaping the landscape of the business world of the future. American engineering education must respond proactively to ensure that its graduates thrive in the increasingly competitive global economy of tomorrow.

Educational studies and reports by key organizations are in agreement about many of the skills that must be developed in students. Though many of these skills can be imparted to students in traditional curricula, there is a growing recognition of the need for more participatory, "real-world" educational methods.

The academic community recognizes that scholarly activity should be more broadly defined, including, among other things, both teaching and applied research. Concern has been expressed over the proliferation of publications encouraged partly by overly narrow tenure requirements. These concerns could be met by an educational approach that allows faculty members to pursue research goals while they educate students at the same time.

The CEO Program has been presented as an educational endeavor that has the potential to address all of the factors mentioned above. Cross-disciplinary teams of students of various academic levels will work to develop and commercialize intellectual properties. Faculty members will be encouraged to participate as team mentors and to co-invent products with those teams. Student and faculty participants will share in the profits generated by the intellectual properties they develop. Revenue (from the commercialization of intellectual properties) must be directed back into the CEO Program to defray operational expenses, at least in part.

Student participants in the CEO Program will be able to develop many of the critical skills they will need to succeed in the marketplace of the future as they work on developing and commercializing real intellectual properties. The reputation of the University will be enhanced as intellectual properties are successfully commercialized. Faculty members may be able to develop and commercialize more of their research results. Finally, intellectual properties developed by CEO Program participants have the potential to produce wealth and jobs for the State of Virginia and the Nation.

All of that being said, however, several challenges must be overcome before the CEO Program can be successfully implemented. Seed funding must be obtained to cover the costs associated with starting this new educational program. University resources must be made available. Finally, many people must come to see the value of the CEO Program and be willing to support its implementation. Students must be encouraged to think creativity. Though none of these challenges appear insurmountable, neither are they trivial. The concerted efforts of many people will be necessary to bring about the successful realization of the CEO Program.

In conclusion, it is clear that something must be done to improve the education of tomorrow's engineers. I suggest that the CEO Program provides an excellent educational opportunity, offering great potential benefit to students, to the University, and to the State and the Nation. Therefore, I recommend that the College of Engineering at Virginia Tech pursue the implementation of the CEO Program.

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Appendix A

Noteworthy Entrepreneurial Programs Nationwide

A. Engineering Entrepreneurs Program (N.C. State) [69, 70]

> The Engineering Entrepreneurs Program is an experimental course offered in the Department of Electrical and Computer Engineering at North Carolina State University. ... [It] is an attempt to bring engineering design to students early in their academic careers [69]. Within each group, the students organize themselves to handle the various aspects of running a high-tech business: research, development, production, marketing, etc [70].

Attractive Features:

- Focuses on many aspects of entrepreneurship.
- Multi-year involvement (freshmen through seniors) with increasing responsibilities.
- Products actually brought to market.
- Lecture series is included.
- Projects initiated by industry or limited to specific topics chosen by faculty advisors.

B. Envisioneering™ (Penn State) [71]

Penn State's Leonhard Center for Innovation and Enhancement of Engineering Education was established in 1991 as a national leader in revolutionizing engineering education. A major program of the Leonhard Center, Envisioneering™, takes a novel approach to educating engineering students in skill areas that will be critical for professional success in industry of the next century. Through close associations with industry partners, the Leonhard Center is identifying industrial needs and developing educational programs that teach students applicable skills. The intent is to graduate engineers who are able to quickly assume leadership positions in technical environments and exploit opportunities that exist in today's highly competitive global markets.

Attractive Features:

- Focuses on imparting specific skills, particularly innovation.
- Students are involved in project work.
- Products are used to improve undergraduate education.

C. The Entrepreneurship Program (University of Iowa) [72]

This is a well-developed curricular program offered at the University of Iowa. Students from any department, particularly engineering, business and healthcare, are encouraged to participate. The University offers an impressive array of courses in subjects related to entrepreneurship as well as a summer practicum to allow students to work in small, early-stage companies to get hands-on entrepreneurial experience.

<u>Attractive Features:</u>

- Well-developed curriculum for entrepreneurship.
- For graduate and undergraduate students.
- For engineering, business, healthcare and other students.
- Technological Entrepreneurship Certificate available to engineering students.
- The students do not work together in small companies to create actual products.

D. Engineering Research Center (Purdue University) [73]

The Engineering Research Center (ERC) at Purdue University is presented here as an example of the kind of "center" that exists at many American universities. Though not specifically targeted at entrepreneurship, the ERC is an excellent educational model.

> The Purdue ERC targets all of the technical activities involved in discrete product manufacturing from early design to final assembly and finishing. Although this perspective is very broad, we believe that we should address directly one of the major problems in manufacturing practices today--the separation of concerns among deparments. The integration of knowledge from different engineering disciplines is a common theme throughout our research and education programs.

<u>Attractive Features:</u>

- Seeks to integrate all areas related to manufacturing (gives breadth of education).
- Recognizes critical importance of innovation.
- Real-world research and projects.

E. The Learning Factory (Penn State, Univ. of Washington, Univ. of Puerto Rico-Mayaguez) [74]

> The Learning Factory is a new practice-based curriculum and physical facilities for product realization. Its goal is to provide an improved educational experience that emphasizes the interdependency of manufacturing and design in a business environment....Industry partners provide real-world problems and are the customers for students in our senior capstone design courses...The Learning Factory is the result of a desire to graduate better engineering professionals with technical competence in engineering science fundamentals as well as professional skills to effectively compete in today's marketplace.

<u>Attractive Features:</u>

- Focuses on imparting technical and professional skills to students.
- Real-world problems addressed.
- Wide collaboration (3 universities and 100 industrial partners).
- Emphasizes the integration of design and manufacturing

F. Engineering Design / Analysis (course at Univ. of Nevada - Reno) [75]

This is a single course offered at the University of Nevada and therefore differs greatly from the "ideal entrepreneurial program" described above. It is included as an example of the kind of courses that exist in many universities throughout the nation and world. Many of the courses reported by Vesper [68] bear similarities to this one.

> ...the University of Nevada, Reno (UNR), has as one of its courses a senior-level undergraduate course... This course takes a very "hands-on" approach to teaching electrical engineering students the concepts of innovation and entrepreneurship. The basic goal of this class is for students to experience the product development process as well as how to start a new company.... students are separated into groups and form companies known as E-teams, they generate a few product ideas, evaluate each of the ideas and choose one to explore, develop the product idea into a functional prototype, and finally perform market/financial analysis to determine if the product could sustain an actual business.

Attractive Features:

- Focused on entrepreneurship.
- Includes project work and a lecture series.
- Students generate, evaluate and develop their own products.
- MBA students involved.

Appendix B

Virginia Tech Intellectual Properties, Inc.[*]

Virginia Tech Intellectual Properties, Inc.

VIRGINIA TECH
INTELLECTUAL PROPERTIES, INC

1900 Kraft Drive, Suite 107
Blacksburg, VA 24060
(540) 231-3593
FAX (540)231-5207

Contact Mike Martin (mike@vtip.org) for more information.

VTIP Homepage

[*] These pages, used with VTIP permission, can be found on the VTIP homepage (http://www.vtip.org).

Virginia Tech Intellectual Properties, Inc.

VIRGINIA TECH
INTELLECTUAL PROPERTIES, INC

Executive Vice President: Michael J. Martin
Director: Ted Kohn

Purpose | Goals | Students | Accomplishments | Patents | VA Licensees

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The Performance of Virginia Tech Intellectual Properties, Inc.

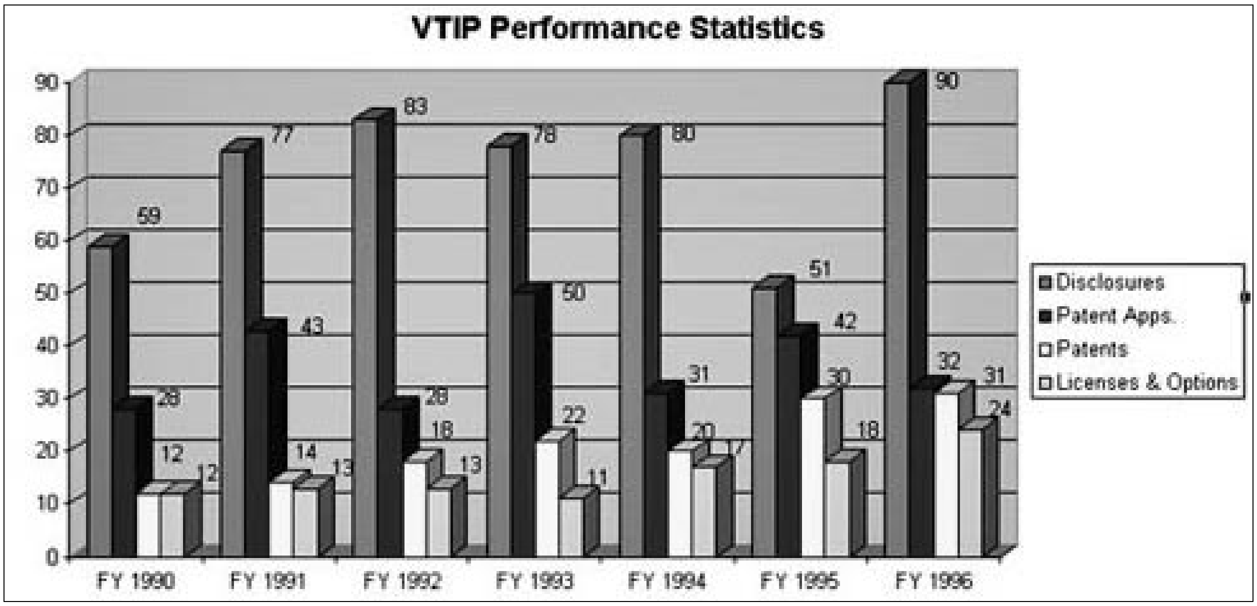
(Image omitted) Click to view larger image

The cultural climate of Virginia Tech is conducive to goal oriented multi-disciplinary research to an extent greater than many universities. This climate combined with
the sensitivity of faculty and students to the potential commercial utility of research results, creates a significant number of invention disclosures many of which can
be legally protected (by copyright, patent, etc.) and utilized for the economic benefit of all concerned.

VTIP, Inc.'s mission is to support Virginia Tech through maximizing the return to the University from its research investment by balancing the following:

- income generated by licensing and other activities related to university intellectual property;
- sponsored research funding from licensees;
- creation of new or start-up businesses and jobs;
- dissemination of university expertise to society.

VTIP General Information and Mission



VTIP Performance Statistics

An Intellectual Property Road Map or,
What to do with the Results of a Good Idea

Have you ever developed an idea or made a discovery that you felt sure would benefit the entire human race -- or least a few folks -- and would make a few bucks too? Well, of course. But then you shelved it because it would take too much time and be too much trouble to protect and market. Right?

Not necessarily. Getting technology through the patent process and into the market place, while not a cinch, is not too difficult or expensive because you don't have to do it by yourself. Virginia Tech's Office of Sponsored Programs and Virginia Tech Intellectual Properties, Inc. (VTIP) have developed a process which simplifies the role of the creator of the intellectual property, and has the potential to benefit you and the university.

Here's the Short Version of How it Works:

You conduct research which results in an invention. In most instances, the invention is owned by the university because you used university resources; however, you share in the results of the intellectual property. The Intellectual Properties Committee recognizes the value of the property and wants it to be protected and, if possible, marketed. You assign it to the university, and the university assigns it to VTIP. VTIP markets the property; the property makes money. VTIP recovers documented expenses and administrative overhead. You get 50 percent of the net, your department gets 10 percent, and VTIP gets 40 percent. The 40 percent covers protecting and marketing projects that aren't generating money yet -- it's the money you didn't have to spend up front. Soon, when more intellectual properties are earning more money, VTIP will be providing funds to support university research.

1. Creation
2. Assessment
3. Protection
4. Marketing

VTIP Intellectual Property Road Map

Virginia Tech Intellectual Properties, Inc.

Creation | Assessment | Protection | Marketing

A. Intellectual Property: CREATION

1. You have an idea for research. !!!!
2. Develop the preliminary scope and budget.
3. Search for and contact sources of funding.
   (Help is available from the Research Opportunity Office, 231-9352, and Research Support Services, 231-9353).

   Private sector funding, proceed to step 4
   Public sector funding, skip step 4 -- proceed to step 5

4. Advise the sponsor contact of Virginia Tech's intellectual property policy position.

   An intellectual property clause will define the rights of both parties. Make sure it is clear that the law of Virginia is the applicable law, and that the university has the right to publish -- although confidentiality can be maintained for six to 12 months. By state law, the university retains ownership, but the sponsor has first option to license. The intellectual property manager can respond to questions and/or help develop mutually satisfactory intellectual property arrangements.

5. Develop a research proposal, with assistance from the Office of Sponsored Programs regarding budget and from the intellectual property manager regarding intellectual property and publications clauses.

   The Office of Sponsored Programs is located in 301 Burruss. Call 231-5283 for support in preparing the proposal package. Ted Kohn, the intellectual property manager, is located at 1900 Kraft Drive, Suite 107. His phone number is 231-3593.

6. Negotiate and sign a research project agreement.
   (Office of Sponsored Programs and the researcher).

7. Carry out the research.
8. Review the results for commercial potential.

   No potential, proceed to step 9.
   Has potential or not sure, proceed to step B.

9. Publish the results, if indicated, and/or prepare a final report.
10. Advise the sponsor that there is no invention.
11. Use the results to create another research idea or project.

VTIP Intellectual Property Creation Guidelines

Virginia Tech Intellectual Properties, Inc.

Creation | Assessment | Protection | Marketing

B. Intellectual Property: ASSESSMENT

1. Fill out an Invention Disclosure Form (available on the PROFS INFO SYS or from VTIP); OBTAIN ALL REQUIRED SIGNATURES (all inventors, principal investigator, department head); submit the form to:

   Intellectual Properties Manager
   Virginia Tech
   Intellectual Properties, Inc.
   0517

2. The intellectual properties manager submits the disclosure to the Intellectual Properties Committee to determine ownership.

   a. If the researcher owns the invention, assessment ends. The researcher can keep the intellectual property or request VTIP evaluation (step 3) and negotiate the management.

   b. If Virginia Tech owns the property but there is private sponsor a-priori rights, assessment may end, the sponsor may license the invention, pay for patenting, and pay royalties, depending on the contract's IP clause. Proceed to step A-5 or B-2c.

   c. If Virginia Tech owns the property, the researcher assigns the intellectual property to the university, who assigns it to VTIP. Proceed to step 3.

3. The intellectual properties manager submits the disclosure to the VTIP Intellectual Property Evaluation/ Coordination Board and to the Virginia Center for Innovative Technology (CIT).

   A board member visits with the researcher, solicits outside opinions on the technical and economic potential of the property, and makes a presentation to the board on whether the property ought to be pursued and on its priority.

VTIP Intellectual Property Assessment Guidelines

4. VTIP and CIT meet to decide whether the intellectual property should be protected and/or marketed and who should do what.

a. If both say no, the intellectual property may be sent to an outside private developer for evaluation and marketing, or classified as an Inactive Disclosure.

The intellectual property is listed in the VTIP catalog by title under the “Inactive” category. Interested parties inquiring about these properties are put in direct contact with the inventor(s) for further activity. Upon the inventors' request, title to the property will be reassigned to them, with limited rights and shares of royalty being retained by VTIP and the university.

b. If VTIP or CIT say yes, proceed to C or D, or wait until a patent application is filed (step C-4).

c. If both VTIP and CIT say yes, they decide who will seek a patent and take the lead in marketing. Proceed to step C or D.

CIT emphasis is on economic development in Virginia, and VTIP emphasis is on marketing intellectual properties and developing research funds for the university.

Share of net depends on how protection and marketing duties are divided\ . If the CIT patents and markets, VTIP receives 75 percent; if VTIP does both, it receives 95 percent, with variations in between. The inventor's share is 50 percent of VTIP's net.

VTIP Intellectual Property Assessment Guidelines (continued)

Virginia Tech Intellectual Properties, Inc.

Creation | Assessment | Protection | Marketing

C. Intellectual Property: PROTECTION

1. If the decision is to patent, VTIP or CIT will fund the process. A patent attorney with appropriate technical expertise is selected. Proceed to 2.

   If the decision is to copyright, the researcher is advised to put “copyright” notices (c) on all material sent out. The copyright can be registered if there is commercial interest; skip to D.

2. The attorney works with the inventor to develop and draft a complete and thorough patent application.

   Close inventor/attorney cooperation in this key step is critical in obtaining a good patent.

3. A patent application is filed.

   The application may be rejected several times as the attorney negotiates with the examiner. The attorney's goal is a broad, basic patent, rather than a narrowly defined set of claims. The process may take as long as three years. Publication of results after filing an application is encouraged.

4. A patent is issued or abandoned.

VTIP Intellectual Property Protection Guidelines

Virginia Tech Intellectual Properties, Inc.

Creation | Assessment | Protection | Marketing

D. Intellectual Property: MARKETING

1. A non-confidential explanation of an intellectual property is sent with a letter to mailing lists, seeking commercial interest.

   a. The researcher often can suggest potential licensees.

   b. VTIP has a list of contacts.

   c. A database search is conducted for companies in the field.

2. Publicity in trade and peer-reviewed magazines, and through professional presentations, etc. is encouraged.
3. A license is negotiated.

   a. If the license is to a major business/industry:

   - the researcher has input as to terms,
   - it may include more research (back to step A-2), and
   - the researcher may be hired as a consultant as part of licensing.

   b. If license is to a small company:

   - the research and consulting component may be larger, and
   - equity interest may be a part of the deal.

   c. A new company is started to commercialize the intellectual property.

   VTIP/CIT help find capital and the management team. You may be a member of the management team.

4. Direct sales, usually only for products with limited, well defined markets.

   VTIP provides invoice and collection services, may arrange manufacturing and distribution support services, and can work with originators to develop a business and marketing plan.

VTIP Intellectual Property Marketing Guidelines

Appendix C

Virginia Tech Policy on Intellectual Property[*]

Policy 13,000: Policy on Intellectual Properties

No. 13,000
Subject: Policy on Intellectual Properties
Rev. 0
Virginia Polytechnic Institute and State University
Policy and Procedures
Date: December 2, 1991

1.0 Purpose

Publicly (state) supported universities have the multiple missions of teaching, research, support of the public interest and fostering of economic development of the area/state in which they are located.

Scholarly activities in a university setting create Intellectual Properties (IPs). IPs include research papers, books, software programs, new inventions, journal articles, etc.

The university's mission includes dissemination of IPs in the most efficient and effective manner possible. The identification and optimization of opportunities for the industrial/commercial utilization of some IPs is also part of this mission, as is the protection of the ownership rights of both the individuals and the university.

While many IPs are best disseminated by publication and placing in the public domain, there are a significant number that are most effectively handled by protection under the IP laws (i.e. patenting and copyright) and licensing (or other transfer) to private sector entities, with attendant financial considerations.

Virginia Tech Policy on Intellectual Property (page 1)

[*] This document is not copyrighted. Taken from (http://www.vt.edu/vt97/misc/policies/13000Policies.html) on 12 December 1997.

This Policy is designed to establish the rationale and the mechanisms to:

1. Establish ownership criteria and resolve ownership questions if such arise.
2. Define the responsibilities, rights and privileges of those involved.
3. Develop basic guidelines for the administration of the IP Policy.

2.0 Policy

2.1 Organization

The Intellectual Properties Committee shall be chaired by the Associate Provost for Research and have the following membership:

1. Twelve at-large members of the Faculty/Staff
2. One member representing the Staff Senate
3. One member representing the Graduate Student Assembly
4. One member representing the Student Government Association
5. The Vice Provost for Research and Dean of the Graduate School (ex-officio)
6. A Vice President of VPI&SU (ex-officio)
7. A representative from the office of the General Counsel of VPI&SU (ex-officio)
8. Intellectual Properties Manager of VPI&SU (ex-officio)

(IPC Chair and ex-officio members may choose ad-hoc or permanent designees.)

A. Qualifications:

At-large IPC members shall have professional background and expertise spanning the university's fields of endeavor, experience in patent and copyright matters, experience and interest in the economic/marketing aspects of technology transfer and personal contacts which they can draw on to assess technico-economic merit of individual IPs.

Individually each IPC member should have the following characteristics:

1. Background and experience to contribute to at least two of the areas outlined above.
2. Desire to be involved with matters relating to IP utilization.
3. Willingness to devote at least 6-10 hours per month to IPC matters.

Virginia Tech Policy on Intellectual Property (page 2)

B. Nominations/Selection:

1. At-Large Members:

The Commission on Research in consultation with the Faculty Senate shall solicit nominations of qualified individuals from multiple sources (i.e. individual Faculty members, Department Heads, Deans, University Administration, Commissions, Faculty Senate, etc.), endorsed by pertinent Department Head(s) and approved by pertinent Dean, and shall prepare a slate of nominees (at least equal to twice the vacancies and representing all colleges of the university).

2. Staff, GSA, SGA Representatives:

Each organization shall nominate at least two individuals for each position.

C. Appointment:

The President shall make all appointments. All at-large terms are for three years. Staggered terms to assure continuity are desirable. Staff Senate, GSA, and SGA representatives are appointed for one year terms. All members may be reappointed. Interim appointments to serve incompleted terms shall be upon recommendation of IPC Chair in consultation with IPC membership.

2.2 Authority and Responsibility of the Committee

The IPC shall have the following authority and responsibility with respect to Intellectual Property:

A. To develop and recommend university policy and policy changes dealing with IP to the Commission on Research.

B. To review all invention disclosures submitted by VPI&SU faculty, staff and/or students for:
   1. Complete and appropriate disclosure of individuals involved in the invention and/or creation of the IP.
   2. Determination of IP ownership by university, originating individuals, research sponsors and/or governmental agencies.
   3. Examination and recommendation to the Provost for disposition of (1) and/or (2) above in those cases where a dispute exists.
   4. Coordination of evaluation and recommendation to Virginia Tech Intellectual Properties, Inc. (VTIP) of technical merit, economic potential and protection/marketing priority.

Virginia Tech Policy on Intellectual Property (page 3)

C. To make recommendations to the Provost for the sharing of royalties between the university and the authors or inventor(s) of the IPs owned by the university.

D. To promulgate such guidelines and procedures as may be necessary for the implementation of this Policy.

2.3 IPC Working Groups

In order to effectively discharge its responsibilities, the IPC will establish the following working groups:

A. Ownership Review Group: This group shall be composed of the staff, GSA, SGA representatives and three at-large members of the IPC (selected by the IPC Chair and serving for a one year term) and chaired by the IP Manager. The group shall meet on a regular basis (monthly as needed) with the following agenda:

1. Review all disclosures submitted.
2. Confirm university ownership for those disclosures in which originator(s) have indicated VPI&SU ownership.
3. Review that sponsor ownership/rights have been ascertained and cleared.
4. Review, discuss and reach preliminary conclusions on those disclosures in which originators claim ownership, forward disclosure/recommendation to full IPC.
5. Assign each disclosure to a presenter for evaluation and review at a subsequent meeting of the Evaluation Coordination Board.

B. Evaluation Coordination Board: This group shall consist of the full membership of the IPC and be responsible for advising the IP Manager as to:

1. The technical merit of the disclosure.
2. The market/economic potential of the IP.
3. The novelty/nonobviousness (i.e. patentability) of the invention (if applicable).
4. The priority of undertaking protection/marketing.

C. Inventorship Review Group: This group, composed of three members of the IPC (appointed ad-hoc by the Chair of the IPC) and chaired by the Vice Provost for Research and Dean of the Graduate School shall be convened when required by the existence of an inventorship/authorship disagreement concerning a given disclosure; such disagreement having been brought to the attention of the IPC Chair by any member of the faculty, staff, student body or administration of VPI&SU.

Virginia Tech Policy on Intellectual Property (page 4)

It will be the responsibility of the IRG to gather all available facts from all concerned with the IP and, after appropriate analysis, attempt to mediate a resolution of the conflict satisfactory to all concerned. Failing that, the IRG shall provide the IPC with a compendium of the background, a summary of the conclusions and a preliminary set of recommended solutions, for their deliberation and formulation of recommendations to the Provost.

2.4 Policy Guidelines

This section outlines the criteria to be used by the IPC and its working groups in their deliberations, findings and recommendations. To the extent that individual questions are not specifically addressed, these guidelines will, at the least, give a general indication of intent and philosophy and allow proper interpretation.

A. Ownership of IPs

For purposes of this policy creations are divided into two groups:

1. The traditional results of academic scholarship, i.e. textbooks, literary works, artistic creations and artifacts.
2. The novel results of research such as products, processes, machines, software, biological technology, etc.

Intellectual properties in the first (traditional) group are considered to make their full contribution to the university's benefit by their creation and by continued use by the university in teaching, further development, and enhancement of the university's academic stature; the presumption of ownership is to the author(s). Thus, unless there is explicit evidence that the work was specifically commissioned by the university, the IP rights remain with the author(s) and the university rights are limited to free (no cost) use in teaching, research, extension, etc. in perpetuity.

In the second group, the strong presumption of ownership is to the university (with the originator having a right to share in the benefits derived therefrom). Thus unless there is convincing and explicit evidence that the IP was developed without the use of university resources and/or facilities (which may include but is not limited to any of the following: use of equipment, lab or office space, university time of originator and/or personnel under his/her control, funds supplied by the university and/or funds originating from sponsored research projects and/or donations to university/affiliated companies, etc.) ownership of the IP rests with the university and the originator(s) are obliged to sign the appropriate legal assignment documents upon request.

Virginia Tech Policy on Intellectual Property (page 5)

Within the above general guidelines, the following situations are more specifically defined:

1. Sponsor Rights: In the case in which an IP is generated as a result of research funded by a private sector company under a sponsored research project, the IP rights of the sponsor as defined in the applicable clauses ("Patents & Copyrights," "Intellectual Properties," "Inventions," etc.) of the Sponsored Research Agreement (as approved by the Associate Provost for Research and signed by an authorized officer of the university) shall take precedence over the rights of the university/inventor(s). Any residual rights not accruing to the sponsor shall be as defined in the general guidelines above.

2. Federal Agency Rights: Research projects sponsored by an agency of the federal government have statutory IP rights that are limited (in almost all cases) to a non-exclusive non-transferrable royalty-free license to any patent generated by the research, provided the inventor(s)/university advise the agency in a timely manner of their intent to retain their rights and provide for legal protection (i.e. patenting). It is the responsibility of the researcher to advise the agency of the creation of the IP and (with the assistance of the university IP manager) advise of the protection steps being undertaken. The residual rights not belonging to the sponsoring agency shall be as defined in the general guidelines above.

3. Student Ownership: Ownership of IPs developed by students who are also employees of the university will be determined by the rules which apply to all university employees. IPs generated by students not employed by the university and not using university resources of at least $10,000 in their generation will be owned by the student but subject to any applicable prior rights of private sector or government sponsors and to the right of the university to use the IP internally at no cost.

4. Joint Inventorship: For IPs generated by a team of inventors in which one or more are not members of the faculty/staff/supported students, each inventor is usually entitled (by law) to shared ownership of the entire right. The university's claim to the shares of university-associated inventors will be as outlined in these guidelines. Ownership of outside inventors will vest in them or their assignees.

5. Special Situations: In the event that an IP ownership situation arises which is not addressed in either the general or specific guidelines outlined above, the IPC shall make a recommendation based on the spirit of the guidelines. A record of the rationale used to arrive at their recommendation shall be kept and used as a precedent for the handling of future Special Situations if applicable.

Virginia Tech Policy on Intellectual Property (page 6)

B. Obligation to Disclose

While it is recognized that faculty mission and expertise is concentrated and directed in areas other than commercial utilization, originators of new technology are strongly encouraged to err on the side of submitting a disclosure when doubt as to its commercial potential exists in their mind. Timely (i.e. before publication or other enabling non-confidential disclosure) submission of a disclosure to the university may also be critical to the value of the IP and is strongly encouraged.

To the extent (and as soon as) the researcher/inventor/creator obtains research results that may be considered an IP and recognizes that they may have potential for commercial utilization there exists an obligation to bring these results to the attention of the university in the form of a disclosure.

If, in the absence of a timely disclosure, commercial utilization of a technology takes place with the direct or indirect involvement of the originator(s) but without involvement by the university it will be deemed that the originator(s) have not fulfilled their obligation to disclose and the university may:

1. Take whatever legal and/or business action is indicated to protects its rights and rightful share of financial benefits.
2. Deny to originator(s) any share of revenues which would otherwise accrue to them under this policy.

C. Revenue Sharing

Revenues generated by the successful commercialization of IPs owned by the university (whether or not protected by patent and/or copyright) shall be shared equally between the university and the originator(s) of the IP, subject to the conditions and exceptions outlined below.

1. Revenues subject to sharing include royalties, licensing fees, incentives, etc. received by the assignee licensor organization, less the costs/expenses described below. Specifically excepted from sharing are payments received and designated for specific purposes such as sponsored or unrestricted research grants, services to the university, research equipment and/or materials, consulting fees to researchers, etc. These payments will go directly to the designated entity and purpose.

2. Also excepted from sharing are revenues resulting from:

   A. Tasks and/or activities specifically and explicitly assigned to employees by an administrative unit of the university, or

Virginia Tech Policy on Intellectual Property (page 7)

B. Activities and/or tasks clearly defined in the written, university approved, policy of an administrative unit of the university.

   Such revenues, flowing through the university assignee organization, will accrue to the originating administrative unit of the university net of development costs.

3. Expenses to be subtracted from gross revenue before sharing shall be limited to documented direct and indirect costs for protection (patenting), marketing and development of the IP.

   Specifically excluded are costs incurred in the generation of the IP (i.e. research costs). Development costs shall include (but not be limited to) payments made to (or retained by) non-affiliated organizations (e.g. Research Corp. Technologies, CIT, etc.) involved in the process of commercializing the IPs owned by the university.

4. Non-cash compensation for rights to an IP may be accepted but only with the informed consent of the originator(s) of the IP.

5. The share of net revenue not paid to the originator(s) (50 percent) shall be applied as follows:

   A. A portion equivalent to at least 10 percent of total net revenue may be distributed to the originator(s)' primary unit(s) (e.g. Departments, Centers, etc.).

   B. The remainder to the university assignee organization (VTIP).

D. Management Responsibility

Virginia Tech Intellectual Properties, Inc. (VTIP), a non-profit corporation affiliated with the university has been established and charged with the mission of protecting and utilizing IPs for the benefit of the university.

All IPs assigned to the university shall flow to VTIP by assignment for operational management. The IPC (through its Evaluation Coordination Board) should make appropriate inputs and recommendations as to disposition and priority of individual IPs. Originator(s)' inputs/suggestions to VTIP are also appreciated.

E. Right Of Appeal

The originator(s) of an IP covered by this Policy shall have the right to appeal application of the policy to the IPC.

Virginia Tech Policy on Intellectual Property (page 8)

The IPC will formulate recommendations relative to each such appeal, and will forward both the appeal and its recommendations to the Office of the Senior Vice President and Provost in a timely manner. The Provost will determine the university's response to each appeal, and will so notify the originator(s) and the IPC.

If the originator(s) disagree with the IPC recommendation regarding ownership, a written appeal to the Provost must be filed within (30) thirty days of receipt of notification of the IPC recommendation. This appeal should contain an exposition of the facts as seen by the originator(s), any information they deem pertinent to the case, as well as any applicable citations of policy guidelines. A copy of the appeal document should be sent to the IPC via its Chair.

Upon receipt of the appeal, the Provost may elect to consult with any and all concerned prior to reaching a decision in the case.

In the event that any member of the university (faculty, staff or student) perceives and/or becomes aware of any irregularity in the inventorship/authorship of an IP disclosed (or about to be disclosed) to the IPC he/she should bring it to the attention of the other inventors/ authors involved and/or the Department Chair(s) concerned in an attempt to resolve the conflict equitably and amicably. Failing such resolution, the facts of the cases should be submitted in writing within (30) thirty days to the Vice Provost for Research and Dean of the Graduate School (with copy to the Chair of the IPC) with a request for review by the Inventorship Review Group of the IPC.

Upon receipt of such a request, the IRG shall review the facts of the case, convene a hearing for all concerned parties, reach a conclusion and present a synopsis of the case and a recommendation to the full IPC who will, in turn, make a recommendation to the Provost.

Virginia Tech Policy on Intellectual Property (page 9)

3.0 Procedures

4.0 Definitions

5.0 References

Policy Memorandum No. 73, “Policy on Intellectual Properties,” issued March 4, 1987

Policy Memorandum No. 121, “Policy on Intellectual Properties,” issued December 9, 1991

6.0 Approvals and Revisions

Revision 0

Approved by University Council: November 17, 1986
Approved by the President: November 17, 1986
Approved by Board of Visitors: December 5, 1986

Revision 1

Approved by University Council: December 2, 1991
Approved by the President: December 2, 1991

Virginia Tech Policy on Intellectual Property (page 10)

Appendix D

Proposed CEO Program Alumni Survey

Personal Information

1. **Age**: _____
2. **Gender**: _____ M _____ F
3. **State of residence:** ____________________

Scholastic Information

1. **What were your academic major(s), degree(s) and year(s) of graduation from Virginia Tech?**

MAJOR	DEGREE	YEAR
____________________	____________________	____________
____________________	____________________	____________
____________________	____________________	____________

2. **Did you get work experience in your field during your years in college?**

   ___ Yes, as a co-op / intern for ____ semesters at ______________________________
   (company name)

   ___ No.

3. **What was your grade point average upon graduation?** ____________ (on a 4 point scale)

Employment Information

1. **Self-employed**

   a. **___ Full-time self-employed**

   ___ Part-time self-employed

   b. **Description of work / company**: ____

   ____

   ____

2. **Employed by other**

   a. **What is your organization's primary business at your location?**

   ___ Communications
   ___ Construction
   ___ Consulting
   ___ Education
   ___ Finance, Insurance
   ___ Government
   ___ Manufacturing
   ___ Trade
   ___ Transportation
   ___ Utility
   ___ Other ______________________ *(please specify)*

   b. **What is your primary function in your organization?**

   ___ General Management, Corporate Official
   ___ Functional Management, Department Head
   ___ Supervisor of Technical Personnel
   ___ Engineer
   ___ Sales
   ___ Educator
   ___ Student
   ___ Consultant
   ___ Other ______________________ *(please specify)*

3. **Employment History:**

   a. **How long have you been in your current position?**

   ____

   b. **How many organizations have you worked for since graduating from Virginia Tech?**

   ____

Participation in CEO Program

1. **For how many semesters did you participate in the CEO Program?** ______________

2. **Why did you participate in the CEO Program?** *(Select as many as apply).*

   ___ I was thinking of starting my own business at some point in the future.

   ___ It seemed like it would benefit me in any career path.

   ___ It was the most attractive student-involvement program offered.

   ___ Other ____

   ____

3. **Which products did your team(s) work on?** (If you participated on more than one team or worked on more than one product, please list each product you helped to develop).

Product Name	Brief Description

4. **In which of the following aspects of product development did you gain first-hand experience in the CEO Program?**

***Please indicate your level of exposure*: 1 - Extensive**
2 - Some
3 - None

___ Ideation (new product concept generation)

___ Market research (learning about competing products, estimating market size, etc.)

___ Developing objectives & deadlines for product development

___ Patent searches

___ Patenting a concept

___ Developing a business plan

___ Developing marketing strategy

___ Addressing product liability concerns

___ Coordinating team consensus for group decisions

5. **Please rate the following aspects of the CEO Program in terms of your personal development:**

	Excellent	**Fair**	**Needs Improvement**
Learning how engineering and business are related	___	___	___
Learning about product development	___	___	___
Developing teamwork skills	___	___	___
Involvement with faculty	___	___	___
Lecture series	___	___	___

6. **To what extent did the following factors motivate you to participate in the Program?**

	Very much	**Somewhat**	**Not at all**
Opportunity to develop *your own* products	___	___	___
Developing *real* products	___	___	___
Potential to get your name on a patent	___	___	___
Potential to make a profit	___	___	___
Good resume material	___	___	___

7. In your opinion, what are some ways in which the CEO Program could be improved?

CEO Program Impact

1. To what extent did your involvement in the CEO Program at Virginia Tech contribute to your personal growth in the following areas?

	Greatly	Somewhat	Little or none
Oral communication	___	___	___
Written communication	___	___	___
Presentation skills	___	___	___
Working independently	___	___	___
Working in a group	___	___	___
Defining / solving problems	___	___	___
Logical reasoning	___	___	___
Leading / guiding others	___	___	___
Innovative thinking	___	___	___

2. How much did the CEO Program contribute to your knowledge of the following?

	Greatly	Somewhat	Little or none
New product concept generation	___	___	___
Market research	___	___	___
Patent search process	___	___	___
Product concept evaluation	___	___	___
Product development process *(The big picture)*	___	___	___
Product protection	___	___	___
Global nature of business	___	___	___
Product liability	___	___	___
Environmental impact of engineering / business decisions	___	___	___

3. In general, to what extent has your participation in the CEO Program benefited your career?

_____ Greatly _____ Somewhat _____ Not much _____ Unsure

Please explain ____

____

____

____

____

Entrepreneurial Experiences

1. **Please indicate the number of times you have engaged in the following activites.** (Indicate as many as apply).

___ Started a business.

___ Bought a (non-franchise) business.

___ Bought a franchise (Franchise name(s): ___________________________________)

___ Received a patent.

a. ___ Subsequently pursued the commercialization of that patent.

b. ___ Have not yet pursued its commercialization.

___ Developed an innovative idea into a profitable product, service, or business.

Please explain: ____

____

____

____

___ Other entrepreneurial (or intrapraneurial) activity: ___________________________

____

____

____

___ Other entrepreneurial (or intrapraneurial) activity: ___________________________

____

____

____

2. **Indicate the extent to which your involvement in the CEO Program contributed to the activities mentioned in question 1 above:**

Very much	**Somewhat**	**Not at all**
___	___	___

Comments: ____

____

____

____

3. **What lead to your decision to start or buy this company?** (Check all that apply)

___ Actively sought out the opportunity

___ Laid off / Fired.

___ Someone presented me with this idea / opportunity.

___ Other ____

____

4. **Please indicate company growth since you started / bought it.**

YEAR	**SALES**	**# of EMPLOYEES**
______	____________	____________
______	____________	____________
______	____________	____________
______	____________	____________
______	____________	____________
______	____________	____________

Additional comments:

Use the space provided to make any other remarks you may have:

Vita

Thomas Jackson Hayes, III was born at a young age in Wilmington, Delaware on August 26, 1971, the second of four children. After completing high school in 1989, he journeyed to Blacksburg, Virginia to study engineering at Virginia Tech. While studying Mechanical Engineering over the next several years, he had the opportunity to work as a co-op student at a chemical plant for the Du Pont Company in Edge Moor, Delaware. In 1994, after five years at school, he graduated, to the delight of his parents and grandparents. From 1994 to 1996, he served as a missionary with The Navigators in Japan, where he learned to speak Japanese and grew to love the Japanese people and culture. In 1996, he returned to Virginia Tech to pursue a Masters Degree in Mechanical Engineering. Upon graduation in 1997, he will embark on his engineering career at Dynax America Corporation, a Japanese manufacturer of automatic transmission components. He hopes to become fluent in Japanese someday so that he can be involved in cross-cultural business and Christian ministry in Japan.