Session 3554

Engineering Entrepreneurship at Penn

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Abstract

Penn’s two Engineering Entrepreneurship courses receive the highest student ratings of all courses offered in the School of Engineering and Applied Science. This paper discusses the importance of engineering entrepreneurship, both from a global economic perspective and from the personal perspective of the engineer. The paper then discusses Penn’s approach to their Engineering Entrepreneurship Program, with particular focus on its differentiation from entrepreneurship courses offered in the business school. The premise of Penn’s Program is that engineers create and lead great technology companies, hiring managers where needed to execute their vision.

Engineering Entrepreneurship and Global Competitiveness

Engineers and scientists create great companies. Why? Because they possess the knowledge and skills of high-tech innovation, the passion to pursue it, and the discipline to succeed. Many of these companies are well known: H-P, founded by two electrical engineers, Bill Hewlett and Dave Packard; Intel, created in 1968 by two physicists, Robert Noyce and Gordon Moore; and IBM, created originally as the Tabulating Machine Company in 1896 by Herman Hollerith, a mechanical engineer. Companies like these, and legions of other current and former high-tech entrepreneurial ventures, are the drivers of America’s economic growth.

America is the world’s leading producer of high-tech products, responsible for about one-third of the world’s production. Moreover, our competitiveness in global markets depends on the diffusion of high-tech innovation into other sectors of the economy. New products, services and processes increase productivity, increase market share, and create entirely new markets. Entrepreneurial companies, and the engineers and scientists who create them, are the sine qua non of this global technological preeminence. Studies find that more than two-thirds of all technological innovation in America, and 95% of all radical technological innovation in America, are attributable to entrepreneurs. In the words of the Assistant Secretary for Technology Policy of the U.S. Department of Commerce, “If innovation and entrepreneurship profoundly shaped the 20th century, they will define the 21st.”

Recent research shows that startup companies play an appreciably greater role in the commercialization of new technologies than do established corporations. Innovations based on academic research are more likely to emerge from small, rather than large, firms. Furthermore, the nimbleness of small firms allows them to bring new products to the market quicker. Small entrepreneurial companies are recognized as being highly efficient vehicles for the speedy commercialization of high-tech innovation.
By their nature, entrepreneurial ventures will take greater risks and pursue more innovative opportunities than will larger, more risk-averse companies. Consequently, large corporations often look to entrepreneurial companies for technology licensing, acquisition and strategic investment opportunities. At the same time, the smaller firms often lack the resources (e.g., capital, manufacturing facilities, sales teams, distribution channels, etc.) to fully develop and market promising products. To compensate for this lack of resources, entrepreneurs often look to partner with large companies. Such mutually beneficial strategic alliances are especially common in the capital-intense pharmaceutical and biotechnology industries.9

Engineering Entrepreneurship and Job Security

In addition to these national and global factors, issues of personal economic security motivate engineers and scientists in the direction of entrepreneurship. Large corporations, which once provided a haven of job security, no longer do so. In 1960, one in four persons went to work for a Fortune 500 firm; in 1980 it was one in five; in 1999 it was one in fourteen. In 1960, it took 20 years to replace 35% of the firms in the Fortune 500; in 1999, it took only 3-4 years. The stable employment opportunity once provided by the nation’s large corporations has weakened. Today more than two-thirds of the new jobs in America are provided by small businesses.10

Also of growing concern to America’s engineers and scientists is the recent trend to offshore sourcing of low-cost engineering talent by multinational high-tech firms. A recent article in Forbes describes Motorola’s opening of a facility and hiring 1,000 engineers and researchers in China, with plans to increase this number to 5,000 within four years. Microsoft, Intel, and Sony have similar plans. The cost to these companies of qualified engineers and scientists is reportedly one-seventh to one-tenth the U.S. cost.11

Similarly, a recent Business Week article describes Intel’s opening of a facility and hiring 950 young engineers in Bangladesh, with plans to increase this number to 3,000 within three years. Texas Instruments, Cisco, Microsoft and Oracle are among some 230 multinational companies seeking to hire 25,000 engineers in India. The cost to these companies of qualified engineers is about one-fifth the U.S. cost.12 Fostered by advances in information technologies - especially the Internet - this globalization of the engineering job market will, no doubt, have an appreciable, and growing, impact on the employment prospects of engineers in this country.

Entrepreneurial Leadership: Hiring Execution

Engineers and scientists will choose to be entrepreneurs because of a driving desire for independence, autonomy and self-reliance.13 Engineers and scientists will be successful entrepreneurs when this desire is coupled with both a passion for technology and effective leadership skills. Based on this premise, the Engineering Entrepreneurship program at Penn is designed specifically to provide the insights, knowledge and skills needed for the successful creation and leadership of high-tech entrepreneurial ventures.

At Penn, we emphasize that our Engineering Entrepreneurship courses are intended for engineers and scientists, and that our mission is to educate future leaders of technology ventures. Drawing upon Abraham Zaleznik’s classic article, “Managers and Leaders: Are They Different,”14 we
differentiate the leader’s task from the manager’s task. Based upon his research, Professor Zaleznik’s characterizes “leaders” as having a desire for autonomy, as being self-reliant, as being visionary, as seeking opportunities for change, as being risk takers, and as being developers of fresh approaches to technical, economic, human and political problems. These leaders are intrinsic, inspirational motivators of people.

“Managers,” on the other hand, according to Professor Zaleznik’s research, prefer to function within organizations, to solve problems and maintain order, to control risk, to reconcile differences, and to focus on how to get things done. Managers tend to be extrinsic, coercive motivators of people. Leaders press for change while managers promote stability. Interestingly, and much to the point of our Program at Penn, Professor Zaleznik finds that leaders have much more in common with scientists and other creative thinkers than they do with managers.

Leaders and managers are both crucial to the success of a company, a point underscored in John Kotter’s article, “What Leaders Really Do.” Their skills complement each other in thriving organizations and, indeed, successful entrepreneurs often possess both leadership and managerial qualities. However, seasoned partners of top-tier venture capital firms believe that a visionary leader with a passion for technology is critical to the successful creation and growth of a high-tech venture. For an entrepreneurial startup, managers are important, but a visionary, passionate leader is paramount. In the words of one nationally recognized and respected venture capitalist, “Visionary engineers are America’s heroes. We can hire execution.”

Penn’s Engineering Entrepreneurship Program

Designed specifically for students of engineering and applied science, Penn’s 2-course engineering entrepreneurship sequence appropriately resides in, and is taught by faculty of, the School of Engineering and Applied Science. Courses are approached from the perspective of the student whose primary interest is in technological innovation, whose primary concentration is on engineering and science courses, and who has little or no prior business education. As non-technical electives, they are designed to supplement a student’s engineering education. These courses focus on the roles of inventors and founders in high-tech ventures. Emphasis is placed on the entrepreneurial leadership role, decisions the founder will face, and the sequential risks and determinants of success during the venture’s early growth phase. While stressing the importance of disciplined management, we emphasize that these courses are about high-tech venture creation and leadership, not business management. For the latter, interested students are referred to excellent management courses at Penn’s Wharton School of Business.

The two courses are each cross-listed at both undergraduate and graduate levels. The first course is offered every semester and provides an introduction to the early phases of a high-tech venture. It investigates the knowledge and skills needed to recognize and seize an entrepreneurial opportunity, and then successfully launch a startup or spin-off company. This course focuses on the key areas of: (a) intellectual property, its protection and related strategies; (b) evaluating the market viability of new high-tech ideas; (c) shaping technology-driven inventions into market-driven products; (d) developing defensible strategies for high-tech product positioning, marketing and operations; (e) acquiring the resources needed to start a new venture, e.g., people, financing, strategic partners, etc.; and (f) a founder’s leadership role in the high-tech venture.
The second course is offered in the spring semester only and investigates the necessary steps for planning a high-tech venture. It provides students, working in teams, an opportunity to develop and present a high-tech business plan. This course investigates the key elements of planning an entrepreneurial high-tech venture including: (a) defining the venture’s industry and market; (b) developing strategies for high-tech product positioning, marketing, distribution, sales, operations, management and development; and (c) preparing a financial plan. This course is taught through the use of classroom lectures, discussions of assigned readings, and the stepwise preparation and presentation of a high-tech business plan by student teams. The plans are ultimately presented to and critiqued by an experienced blue-ribbon panel of investors, advisors and entrepreneurs. Effective written and verbal presentation skills are emphasized throughout the course.

In view of the unprecedented ratings of these two courses (as described below), it was tempting to expand the Engineering Entrepreneurship program with additional related courses. Thought was given to creating a minor field of study in engineering entrepreneurship. After due consideration, however, it was decided that the future success of our engineering students as entrepreneurs will be driven, not by more entrepreneurial business courses, but by their passion for technology and depth of knowledge in their respective engineering disciplines. This is the root of high-tech innovation. We feel that additional courses in areas such as entrepreneurial finance, entrepreneurial marketing, or entrepreneurial management, while being important to the execution of a startup business, are distractions from the creative technological focus of engineering entrepreneurs. The engineers and scientists who create tomorrow’s high-tech ventures will do so based upon their technological excellence, and the sense to “hire execution.”

EAS345/545: Engineering Entrepreneurship I

The balance of this paper focuses on the first course in the 2-course sequence, Engineering Entrepreneurship I. Exhibit 1 presents a syllabus for this course for a representative 26-session semester. This course includes four modules, which span the creation and early growth phase of high-tech entrepreneurial startups.

- The first module provides an overview of the entrepreneurial experience that, for most of our engineering students, is their first introduction to the field of business.
- The second module investigates the development of high-tech ideas and inventions into market-driven products, and then the strategies for launching these products.
- The third module covers the entrepreneur’s task of assembling the resources needed to execute his vision; e.g. human capital, financial capital, strategic partners, etc.
- The fourth and final module explores the leadership qualities of high-tech entrepreneurs - some successful and some not so.

Module 1: Engineering Entrepreneurship Overview. The opening class, before students have read any course materials, is used to introduce the course, grading policy, website parameters, etc. We then immediately proceed to a discussion of the importance of engineering entrepreneurship, nationally and globally, and its inherent risk-vs-reward parameters. This segues to a summary of key takeaways from the course on ways to significantly enhance the odds of success. We then talk about the over-riding element of trust and the importance of building trust at every transaction along the entrepreneurial path. Finally, we talk about the importance of giving back after the entrepreneur harvests financial rewards from the venture.
Engineers create great companies. In the second class session a case study on Bill Hewlett and Dave Packard, two electrical engineers, helps to underscore this fact and provides an ideal opening assignment for the semester. This assignment also includes a study of “The New Venture,” an article by Peter Drucker on entrepreneurial management in which our students are encouraged to look for explanations for the success of Hewlett-Packard.

A second introductory case study about Vermeer Technologies is rich in content as it follows the path of a software product from its initial conceptualization to its acquisition by Microsoft. For engineering students with no prior business experience, it provides an excellent introduction to the issues facing entrepreneurial leaders. Moreover, the Vermeer case is especially rich in its portrayal of human relationships at play both within the venture and with outside parties.

Module 2: Product Development and Strategy. The second module begins with a lesson on intellectual property, its protection, and its currency value in strategic deal making. Thereafter, this module focuses on a key issue facing high-tech entrepreneurs: engineers invent devices but customers buy products. The transformation of technology-driven ideas to market-driven products is the primary takeaway of this second module. Several readings and cases identified in Exhibit 1 for class sessions 5 through 9 are very effective for the purposes of this module. These are supplemented with techniques such as concept testing, conjoint analysis and perceptual mapping, which are useful tools for assessing customer preferences and perceptions.

Module Two continues with discussions of pricing strategy, marketing strategy and operations strategy. Lectures in this module benefit from material in Geoffrey Moore’s widely accepted treatise, “Crossing the Chasm,” William Davidow’s, “Marketing High Technology,” and Leonard Lodish’s recent book, “Entrepreneurial Marketing.” The Dell Computer case in class session 7 provides a particularly valuable lesson on effective operations strategy and the resulting advantages of cost leadership. Class sessions 8 through 10 then provide insight into entrepreneurial ventures in the life sciences, with particular focus on the time, expense and risk of the FDA approval process. The module concludes with a discussion of negotiating skills, reinforced with a case study of a strategic investment deal between a high-tech startup and AOL.

Module 3: Gathering Resources. Gathering of human resources, mentors, advisors, strategic partners, customers and other stakeholders is discussed often in cases throughout the semester. The third module pays particular attention to the gathering of financial resources. From the beginning of this module, we emphasize the fact that more than 80% of America’s fastest growing companies are launched without tapping the “big money model”, i.e., so-called “angel” investors and venture capital. Founders’ personal resources, reinvested profits and, eventually, bank loans, capitalize this large majority of successful ventures. This reality is often lost in many entrepreneurial finance courses that focus on third-party private equity.

The third module then continues in class sessions 13 through 18 to discuss: (i) venture capital firms and the mentoring value they can bring to a startup company; (ii) the preparation and presentation of high-tech business plans - emphasizing the need to be flexible given that 75% of these plans change radically during the early phases of a startup; (iii) term sheets and investment deal structures; (iv) strategic investments by other companies; and (v) the advantages and
disadvantages of initial public offerings. In this latter discussion we emphasize that, while the
IPO may be a desirable “exit strategy” for an investor, it is a “transition,” and not always a
pleasant one, for the entrepreneur. Life as a public company is significantly more onerous,
notably with respect to the time and energy required for investor relations, than that of a private
company. Module 3 concludes with a biomedical case, BioTransplant Inc., dealing with the
process of pursuing an IPO. This particular case also provides an excellent vehicle for
discussing the value of strategic alliances to entrepreneurial ventures.

Module 4: Entrepreneurial Leadership. Throughout the course, case studies introduce our
students to the creators and leaders of high-tech ventures, and to the problems and decisions they
face. In this last module, we use the final month of the semester to focus on leadership styles -
some of which are effective, and some of which are not. The 20th class session discusses
intrinsic (inspirational) leadership compared to extrinsic (coercive) leadership. This leads to the
conclusion that the former is a critical element of success, especially for the talented and self-
motivated people typically involved in high-tech startups. The 21st class session then
investigates the problems incurred when a company falls into chaos because of its leader’s
failure to maintain a focused, competency-driven, and clearly communicated vision.

A favorite reading of our students is the chapter on “Level 5 Leadership” from Jim Collins’
acclaimed book, From Good to Great. Collins’ research finds that great, enduring companies are
typically lead by modest, appreciative, hard-working leaders - not by proud, self-centered,
finger-pointing ones. Most of our engineering students find it easy to associate with the effective
qualities of Collins’ “Level 5” leaders.

The last two cases of the semester present two diametrically opposed sagas of high-tech
entrepreneurial leadership: the story of Sun Microsystems and the story of Momenta
Corporation. The Sun case demonstrates driven, passionate leadership and the launching of a
great company. The Momenta case demonstrates a breakdown of leadership, resulting in a
failure to execute and the demise of a venture. Both cases are rich in content, and reinforce
many leadership and execution lessons from the semester.

Wrap-Up. Our closing lecture transports students to the harvesting of their entrepreneurial
ventures, and begins with a practical discussion of “The Number”, i.e. how much money do I
need to retire? This lesson on personal finance evokes a usually lively discussion of “how much
will I need to live on” as well as disparate views toward personal wealth.

The semester re-cap then begins with a discussion of Abraham Zaleznik’s “Managers and
Leaders: Are They Different” (introduced earlier in this article). Most engineering students find
it heartening to personally associate with the traits of Professor Zaleznik’s “leaders.” We then
segue to a re-cap of our case studies, and a look at the leadership qualities of many high-tech
entrepreneurs to whom we were introduced during the term.

Finally, our students are given a charge to go out, put their education to good use, and make a
difference. Giving back is part of making this difference. They will find great satisfaction one
day, looking at the world, seeing something good in it, and knowing that it would not be there,
were it not for them.
Pedagogic Approach

In the classroom, the course is taught through the use of mini-lectures, case study discussions, and guest speakers. Faculty, including the author, have significant leadership experience in entrepreneurial technology companies. This provides for anecdotal, experiential sidebar discussions that frequently punctuate class sessions. Homework assignments include readings and case studies, essays on the case studies, and problem sets. Student teams also complete a term project evaluating the market viability of an innovative high-tech product or service.

The Case Method. Active classroom discussion of case studies is a significant element of our pedagogic approach. More often than not, this course provides the first introduction of our predominantly engineering students to the case method of learning. This introduction is facilitated by two readings, *Learning by the Case Method* by John Hammond and *The Case Method of Instruction* by Fred Gibbons, which provide helpful guidelines for students on studying a case and on participating in case discussions in the classroom.

During the course of a semester, which at Penn spans 26 to 28 eighty-minute class sessions, we cover 18 to 20 cases as shown on the representative syllabus in Exhibit 1. Each case assignment includes several study questions to help focus the students on important elements of the case. For each case study, students are required either to write a 2-page essay, which is submitted at the beginning of class on the day the case is discussed, or to answer a 10-minute open-notes/closed-book quiz at the beginning of class. Essays are typically due on the first class session in a given week to allow the weekend for preparation, while quizzes are typically given on the last class session in the week. This method of assessment is effective to insure that all students study each case and are prepared for class.

Guest Speakers. Guest speakers are invaluable contributors to our curriculum. In addition to being a fresh voice, they bring a real-time perspective to the class that effectively reinforces and supplements our course content. Students are also afforded the opportunity to meet prominent players in the venture community and expand their personal networks. Five or six guest speakers address the class during the course of a semester, usually in the last half of the semester after the students have had an opportunity to become familiar with the entrepreneurial process. Often our Engineering Alumni Development Office suggests names of potential speakers with whom they are seeking to build a closer relationship. This collaboration has produced mutually beneficial results in terms of both involvement and support from key alumni.

Guest speaker invitations are typically extended to one or two founders of companies in the life sciences, one or two founders of companies in information technologies, a principal player in one of our case studies, and a senior partner from a top-tier venture capital firm. Course curriculum and possible topics are discussed with each speaker beforehand, and each is encouraged to leave at least 30 minutes of class time for a question-and-answer session following his/her presentation. Prior to each guest appearance, the students’ assignment includes reading selected current articles about the speaker and his/her company, exploring the firm’s website, and submitting six questions for the Q&A session. These questions are subsequently graded on the basis of level of effort, insight and relevancy to course objectives.
Term Project. Working in teams of three or four, students evaluate the market potential of innovative high-tech products or services. Topics are provided each semester by Penn’s Center for Technology Transfer, the University’s patent and licensing operation, from a list of recent high-tech disclosures from University laboratories. Each team selects a discovery topic, reviews the disclosure file, meets with the inventor, shapes the discovery into a product, then performs an opportunity analysis to assess the market potential of their product. Primary research in the form of customer interviews, concept testing surveys, and conjoint analyses are encouraged. Finally the students develop a strategy for reaching their market segment(s) and provide a risk assessment. Students submit a 20-page (maximum) report on their findings.

Grade Assessment. Grade assessments are based on: class attendance and participation; essay assignments on the cases; in-class quizzes on the cases and related readings; problem sets; and the abovementioned term project. Attendance and classroom participation comprise 30% of the final grade. Essay assignments, quizzes and problem sets comprise 40%. The term project comprises 30%. Attendance is usually not a problem with this popular class. Nevertheless, students understand that any unexcused absence receives a participation grade of “F” for that class (medical and family emergencies are excused, interviews are not). Substantive participation in class discussion earns an “A” or “A-Plus” for the day; whereas “air time” without substance is penalized.

Student Profile and Feedback

To facilitate participation in classroom discussion, enrollment is targeted at about 40 students, with 50 being the upper limit. A second section was initiated in the spring 2003 semester to accommodate student demand. Junior or senior standing is required of undergraduates. Typically 95% of enrolled students are majoring in engineering or applied science disciplines. The other 5% is comprised of students from the School of Arts and Sciences and the Wharton School of Business. Of the engineering majors, typically one-third are in computer science and telecommunications, and one-third are in bioengineering and biotechnology. Women typically comprise about 25% of the course enrollment. The curriculum is designed for students whose primary interest is in technology, as opposed to business management. Few students have taken prior business courses. There are no course prerequisites for EAS345/545. Successful completion of EAS345/545 is a prerequisite for enrollment in EAS346/546.

Students consistently give top ratings to our Engineering Entrepreneurship courses. EAS345 has received the highest rating of any course offered in the School. Since this elective 2-course sequence was first offered in the fall-1999 semester, enrollment requests have often exceeded class capacity limits. Feedback from recent graduates speaks to the courses’ benefits both in work experiences and in everyday life. “This is a ‘must-take’ course for engineering students.” “By far, after 4 years at (another Ivy university) and 3 at Penn, the best, most interesting and useful class I have ever had.” “This is a demanding course, but well worth it.” “Hands down, the best class I’ve ever taken. I will refer back to it for the rest of my life.”
Acknowledgements

Penn’s Engineering Entrepreneurship Program reflects material extracted from hundreds of relevant books, articles, case studies and journals. It also reflects the advice provided by many highly regarded academicians and practitioners. The foresight to launch this Program is attributable to the leadership of Eduardo Glandt, Dean of Penn’s School of Engineering and Applied Science. For his encouragement and for the opportunity to undertake this tremendously rewarding “second career,” the author is immensely thankful.

Case methodology represents much of the pedagogic approach in our Program. A number of publications provided helpful advice about case teaching. Moreover, hours of conversation with Professors Norm Berg, Louis (By) Barnes and Forrest Reinhart at Harvard, Professor Ed Zschau at Princeton, and Professor Bill Hamilton at Penn, provided invaluable guidance to this teaching art, as did first-hand observations of Professors Zschau and Hamilton in their classrooms.

As the Engineering Entrepreneurship courses were constructed, the author benefited from hours of useful consultations with entrepreneurial faculty members at Penn, Harvard, Stanford, Princeton, Cornell and Colorado. For substantial amounts of course content, the author is especially indebted to numerous members of Penn’s distinguished faculty; to Harvard Professors Norm Berg, Myra Hart, Sam Hayes and Mike Roberts; to Stanford Professors Tom Byers and Tom Kosnik; to Princeton Professor Ed Zschau; to Cornell adjunct John Nesheim; and to Colorado Professor Frank Moyes. Similarly hours of invaluable consultations were held with venture capitalists, patent lawyers, small business advisors, and other practitioners -- too numerous to acknowledge individually -- of high-tech entrepreneurship across the country.
Exhibit 1. Annotated Syllabus:

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<th>Class</th>
<th>Module</th>
<th>Content</th>
<th>Takeaways</th>
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<td>1</td>
<td>Overview</td>
<td>• Introduction: Seizing the Opportunity</td>
<td>The importance of engineering entrepreneurship.</td>
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<td>• READING: The New Venture&lt;sup&gt;25&lt;/sup&gt;</td>
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<td>• CASE: Hewlett Packard: Creating, Running and Growing an Enduring Company&lt;sup&gt;26&lt;/sup&gt;</td>
<td>Why H-P succeeded, in Peter Drucker’s terms.</td>
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<td>Strategic Collaboration&lt;sup&gt;27&lt;/sup&gt;</td>
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<td>• CASE: Vermeer Technologies (A, A-1, B, C)&lt;sup&gt;28&lt;/sup&gt;</td>
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<td>• READING: Legal Protection of Intellectual Property&lt;sup&gt;29&lt;/sup&gt;</td>
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<td>• CASE: Palm Computing, Inc.&lt;sup&gt;30&lt;/sup&gt;</td>
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<td>• READING: Product Development: A Customer-Driven Approach&lt;sup&gt;31&lt;/sup&gt;</td>
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<td>• READING: The Winning Strategy&lt;sup&gt;32&lt;/sup&gt;</td>
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<td>• CASE: CardioThoracic Systems&lt;sup&gt;38&lt;/sup&gt;</td>
<td>Biomedical device product design and marketing.</td>
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<td>The Time-Value of Money</td>
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<td>Biomedical operations strategy. Present value analysis.</td>
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<td>• CASE: Nucleon, Inc.&lt;sup&gt;39&lt;/sup&gt;</td>
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<td>Negotiating skills.</td>
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<td>• CASE: Johnson-Grace&lt;sup&gt;40&lt;/sup&gt;</td>
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<td>• READING: Bootstrap Finance: The Art of Start-ups&lt;sup&gt;41&lt;/sup&gt;</td>
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<td>• READING: Angel Investing&lt;sup&gt;42&lt;/sup&gt;</td>
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<td>The high-tech business plan.</td>
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<td>• CASE: Walnut Venture Associates (A): RBS Group Investment Memorandum&lt;sup&gt;44&lt;/sup&gt;</td>
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<td>Founder’s experiences.</td>
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<td>• GUEST SPEAKER (Partner, venture capital firm)</td>
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<td>• CASE: Visionary Design Systems: Are Incentives Enough?&lt;sup&gt;52&lt;/sup&gt;</td>
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<td>21</td>
<td>The Entrepreneurial Opportunity of Disruptive Technology</td>
<td>• LECTURE: The Entrepreneurial Opportunity of Disruptive Technology</td>
<td>Destructive and disruptive technology. The importance of disciplined, visionary leadership.</td>
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<td>• READING: Exploiting an Age of Disruption&lt;sup&gt;53&lt;/sup&gt;</td>
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<td>• READING: The Spoiled Startup: Too Much Money Is a Bad Thing&lt;sup&gt;54&lt;/sup&gt;</td>
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<td>• CASE: MIPS Computer Systems&lt;sup&gt;55&lt;/sup&gt;</td>
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<td>22</td>
<td>Level 5 Leadership</td>
<td>• READING: Level 5 Leadership&lt;sup&gt;56&lt;/sup&gt;</td>
<td>Leadership style in great companies. Doing what it takes.</td>
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<td>• CASE: Vinod Khosla and Sun Microsystems (A)&lt;sup&gt;57&lt;/sup&gt;</td>
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<td>Failing leadership</td>
<td>• CASE: Momenta Corporation (A, B)&lt;sup&gt;58&lt;/sup&gt;</td>
<td>Failed leadership.</td>
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<td>• GUEST SPEAKER (Principal in case study)</td>
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<td>Information technology company</td>
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<td>• READING: Managers and Leaders: Are They Different?&lt;sup&gt;59&lt;/sup&gt;</td>
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<td>• READING: What Leaders Really Do&lt;sup&gt;60&lt;/sup&gt;</td>
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End Notes and Works Cited.


16 From lectures at the University of Pennsylvania by Andy Rachleff, Partner, Benchmark Capital, Menlo Park CA. Nov 2, 2000 and Nov 14, 2002.


23 EAS345 Engineering Entrepreneurship I received an overall course rating of 3.9/4.0 in the “2001 Undergraduate Course Guide” published by the PENN Course Review. Ratings are based upon Course Evaluation Forms distributed to students in all undergraduate courses at the University of Pennsylvania. This was the highest rating given to any course in the School of Engineering and Applied Science. EAS346 Engineering Entrepreneurship II received an overall course rating of 3.8/4.0, surpassed by one other course in the School. The “EAS” designation denotes a non-department-specific course within the School of Engineering & Applied Science.

24 Five publications, in particular, were very helpful regarding case method teaching skills:


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Tom Cassel joined the faculty of Penn’s School of Engineering and Applied Science in 1999 following a 25-year career of entrepreneurial business leadership. In 2002 he received a full professorship appointment. He earned his B.Sc., M.Sc. and Ph.D. degrees at the University of Pennsylvania, and he completed post-graduate studies in the Harvard Business School’s OPM Program. He has published more than 50 papers and a book.