

AC 2008-1210: USING TECHNICAL ENTREPRENEURSHIP CASE STUDIES TO DEVELOP THE ENTREPRENEURIAL MINDSET IN ENGINEERING STUDENTS

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USING TECHNICAL ENTREPRENEURSHIP CASE STUDIES TO DEVELOP THE ENTREPRENEURIAL MINDSET IN ENGINEERING STUDENTS

Abstract

The flattening of the world is rejuvenating the call for engineering colleges to better educate students to be creative and innovative. In addition, the number of engineers going to work for start-ups and smaller companies continues to rise. The recent growth of entrepreneurship programs and minors aimed at engineering and other technical professions seems to support the hypothesis that engineers who are more entrepreneurially minded are essential to the future technical competitiveness of the country. Many institutions with already packed engineering curricula are struggling with how to better develop the entrepreneurial mindset in their technical and engineering students.

Intercollegiate entrepreneurship education is well underway at The University of Detroit Mercy (UDM). Through support from the Kern Family Foundation (two grants), the Lemelson Foundation (administered by the National Collegiate Inventors and Innovators Alliance), Ford Motor Company, and the Jesuit 100 Association, we have already piloted four new courses and are currently preparing a proposal for a minor in entrepreneurship.

As part of the Kern Entrepreneurship Education Network (KEEN) Program sponsored by the Kern Family Foundation, UDM is developing a number of entrepreneurship case studies which are being integrated into existing engineering fundamental courses. These case studies are intended to illustrate how entrepreneurs have capitalized on their knowledge of specific engineering topics. The aim is to provide routine exposures to successful engineering entrepreneurs and principles of entrepreneurship throughout the curriculum. The ideal, long-term vision is that each engineering course would have one or more corresponding case studies. This paper will summarize the three cases which have been developed and piloted thus far. The materials have been developed using rich media and will be made freely available to KEEN partners and other colleges wishing to utilize them.

Introduction

There is a strong emerging consensus that traditional higher education curricula (business, engineering as well as professional curricula) need to be supplemented with the soft skills attributed to entrepreneurship. The understanding is that a workforce that is entrepreneurial and enterprising will help shield itself and the economy against the various global factors. These benefits are evident whether a person starts a small business, launches a technology start-up, becomes employed by a smaller company or simply excels in a large multi-national corporation.

Stipulating to the need for some entrepreneurship education, the discussion will shift to questions of how, when and where. The simplest mechanism is to include classes on entrepreneurship into the core curriculum. A quick web search reveals that some schools have been effective in integrating entrepreneurship into their core curriculums. Unfortunately, the authors' first-hand experience (UDM is currently in the process of redefining its core curriculum) is that

Entrepreneurship will not be part of the core curriculum at UDM in the foreseeable future. Furthermore, technology and engineering curricula are so overloaded that adding extra content in the form of extra courses is extremely difficult. The question inevitably arises as to what needs to be taken out of the curriculum to make room. There is seldom an easy answer to this question.

One avenue that was developed at UDM is that of the Technical Entrepreneurship case study. These case studies illustrate how a successful entrepreneur capitalized on his/her knowledge of specific technical or scientific topics to create a successful business venture. These short case studies then become part of the relevant engineering or science courses. This approach requires minimal alteration to the existing curriculum.

These case studies are designed to instill the seeds of entrepreneurship in the student audience. By no means are these case studies meant to be a substitute to rigorous courses on Entrepreneurship. The aim is to raise the interest level among the students, make them aware of this important field and give them an overview of the subject. The hope is that they would choose to study Entrepreneurship either as a minor degree or as a set of elective courses. It is in those courses that the all important hands-on training and actual project work will take place.

There is a great ancillary benefit to these case studies in that they allow the student to better appreciate the usefulness of what might be initially construed as a boring and dry technical topic. It is that mutually beneficial relationship that makes it easier for a course instructor to give up a contact hour of his/her class. The authors' research into existing entrepreneurship case materials revealed a large number of cases, but several factors led us to develop our own case studies rather than try to adopt those existing cases. These factors include:

- The focus of the case studies is mainly on the business and entrepreneurship aspects as opposed to on application of engineering principles in an entrepreneurial venture (though many of the products are highly technical in nature).
- The desire for the author's to engage area technical entrepreneurs to begin to build relationships with that community.
- Many of the cases are quite long (i.e., would take more class time than the authors envision being available – at least before the idea catches on and gains wider acceptance at UDM).
- The cases are not typically free; we would like to develop cases that may be freely used by other institutions participating in the Kern Entrepreneurship Education Network (and beyond).

The basic premises of the Entrepreneurship case studies are as follows:

- Relatively short (30-45 minutes or so) Entrepreneurship case studies integrated into existing technical courses.
- These case studies illustrate how an entrepreneur has capitalized on his/her knowledge of specific technical/engineering topics covered in the course.
- Besides illustrating the practical relevance of the subject matter, each case study focuses on few key aspects of entrepreneurship. Collectively, the cases are structured to provide as broad an exposure as possible with minimal duplication of content/topics.
- The aim is to provide routine exposures to successful engineering entrepreneurs and principles of entrepreneurship throughout the curriculum.

- The cases include video footage of an interview with the entrepreneur and will be made publicly available for use at other institutions.
- To strengthen the tie to the course, a relevant in-class exercise, lab, or homework assignment accompanies each case study.
- The long-term vision is that many engineering/technical courses will have a corresponding case study. Case development participation by and sharing of cases amongst other KEEN institutions is one way to quickly develop curricular materials which can have a wide-reaching impact at the participating institutions.

Case Studies

To date, technical entrepreneurship cases have been developed around three different entrepreneurs and their ventures: Jonathan Smith and Wave Dispersion Technologies, Ray Gunn and his work with Somanetics and Clarity, and Matt Younkle and Laminar Technologies' Turbotap. A fourth is currently under development.

Each of the three developed case studies will be briefly summarized below. Keep in mind that the actual delivery of the case studies involves heavy use of video clips of an interview with the subject entrepreneur plus engaging dialog with the students. Hence a paper format renders the presentation comparatively dry and uninspiring. The authors will gladly make available the PowerPoint slides used in presentation of the cases, supplemental materials, and the video clips available for any other instructors wishing to adopt the cases.

Case 1: Jonathan Smith and Wave Dispersion Technologies

Jonathan Smith Case: Background Material

Jonathan Smith and his father, Dennis, motivated by the need for erosion protection for an oceanfront condominium development in New Jersey embarked on what would become Wave Dispersion Technologies (WDT). Their erosion prevention product is a modular and highly engineered marine floating breakwater system shown in Figure 1.



Figure 1. Floating Breakwater System (left) Consisting of an Array of Modules (right)

In addition to erosion protection, WDT has developed another market for their system – namely as a line of demarcation for security purposes. More company background is available on the web¹.

Jonathan Smith Case: Outline of Case Content

To convey the nature of the case study presentation as much as possible without being able to include the video clips or detailed slides for size considerations, a rough content outline is provided below:

- Video: Jonathan Smith defines entrepreneurship and traits of an entrepreneur
- Video: Jonathan Smith explains what distinguishes technical entrepreneurship
- Tech transfer cycle
- More about an entrepreneur from Jonathan Smith and NCIIA/KEEN
- Video: Jonathan Smith explains how beach erosion problem represented a business opportunity
- Review of existing breakwater solutions
- Video: Jonathan Smith discusses the finances of establishing WDT
- Image showing array of modules comprising a waterbreak
- Video: Jonathan Smith explains how WDT got into security barriers
- Video: Jonathan Smith discusses some of the non-technical challenges in creating and marketing their products
- Role of scale model testing in developing the product, including some images of the full size and ¼ scale models
- In-class exercise: The fluids instructor leads the class in a live exercise asking the students to setup the appropriate non-dimensional analysis terms for the scale model testing
- Video: Jonathan Smith discusses exit strategy for WDT

Jonathan Smith Case: Course Integration

This case study is ripe for deeper exploration along a variety of dimensions; for our purposes we chose to focus on the technical aspects of their use of scale model testing to optimize the module geometry and array layout for maximum effectiveness. As such, the case has been embedded into our undergraduate Fluid Mechanics course. The case study is presented after the students have had the lecture on non-dimensional analysis, and, as part of the case study delivery, the students are engaged in an exercise where they are asked how they would proceed to setup appropriate scale model tests/non-dimensional parameters for this situation.

Case 2: Ray Gunn and Somanetics and Clarity

Ray Gunn Case: Background Material

This case study is about a man named Raymond (Ray) Gunn whom Professor Weaver first heard speak at an NCIIA Invention to Venture Workshop at Lawrence Technological University. Ray Gunn has spent his career acting as the principal financial and strategic architect to build concept technologies into commercialized ventures/companies. He has led ten teams through their formation, funding, growth, and ultimate sale or Initial Public Offering (IPO). Additional information about Ray Gunn's background can be found at http://www.wingspanco.com/wst_page2.html.

Somanetics and Clarity are two of the companies resulting from Ray Gunn's efforts. In order to contain the scope of this case study, the focus will be on these two ventures.

Somanetics develops, manufactures and markets the INVOS Cerebral Oximeter (Figure 2), the only noninvasive patient monitoring system that continuously monitors changes in the blood oxygen levels in the brain commercially available in the U.S.⁴

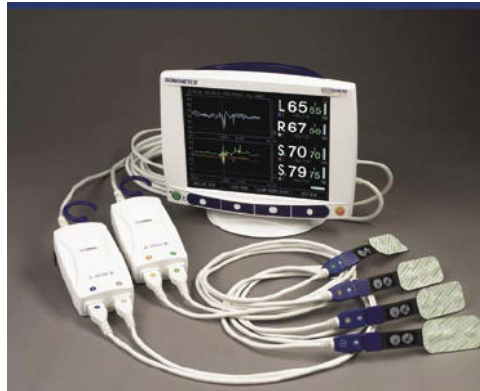


Figure 2. INVOS Cerebral Oximeter (image from somanetics.com)

Prior to the in-class case study presentation, students are given a handout and asked to visit a website to learn more about the Cerebral Oximeter. In addition, depending upon the instructor's intentions with the case study, the students may be asked to review a related patent.

Clarity Technologies is a leading provider of software and services for echo and background noise cancellation in voice-based products. Its Clear Voice Capture technology (CVC) is their principal product; it has found widespread application in a variety of wireless headsets, cell phones, and automotive hands free systems. In March of 2005, Clarity Technologies was acquired by CSR plc (LSE: CSR.L), ("CSR") a wireless solutions provider and leading supplier of Bluetooth technology.

Students are asked to familiarize themselves with Clarity and CVC before the in-class case presentation by visiting <http://www.csr.com/products/cvc.htm>.

A handout the students are given in preparation for the case study is provided as Appendix A.

Ray Gunn Case: Course Integration

The nature of the technical content in this case relates closely with content we normally cover in a Mechanical Measurements course (although many institutions refer to their similar course as Instrumentation). Our Mechanical Measurements course covers a variety of transducers and signal processing techniques used to analyze the resulting data, making for a good discussion as to how this case study relates to the course content. In addition, we are planning to add a lab demonstration of the directional two microphone system similar to what Clarity experimented with early in its history.

This case study went a bit longer than the planned 30-45 minutes intended, so other institutions using this case may wish to eliminate either the Somanetics or the Clarity portions of the case.

To convey the nature of the case study presentation as much as possible without being able to include the video clips or detailed slides for size considerations, a rough content outline is provided below:

- Video: Ray Gunn defines entrepreneurship
- Reflection on that definition and traits of an entrepreneur per NCIIA/KEEN
- Video: Ray Gunn discusses technical entrepreneurship
- Video: Ray Gunn describes his viewpoint on risk and failure
- Video: Ray Gunn explains origins of the Cerebral Oximeter
- Review of how the Cerebral Oximeter works
- Video: Ray Gunn explains more about the technology and how he got involved
- Video: Ray Gunn discusses the process of bringing the Cerebral Oximeter to market
- Video: Ray Gunn explains their approach to IP
- Video: Ray Gunn discusses their manufacturing strategy
- Transition to Clarity Technologies
- Video: Ray Gunn introduces Clarity's Clear Voice Capture (CVC)
- Video: Ray Gunn describes the two microphone value proposition
- Video: Ray Gunn explains how they morphed to a single microphone solution to get to market
- Video: Ray Gunn explains some of the challenges bringing CVC to market
- Details of how CVC works
- Video: Ray Gunn explains how to use a Pain/Pleasure test to screen an idea
- Video: Ray Gunn gives advice on what to do if you have an idea
- Additional idea evaluation suggestions
- Video: Ray Gunn on how he as a VC evaluates an idea
- Video: Ray Gunn when asked when the best time is to become an entrepreneur

Case 3: Matt Younkle and Laminar Technologies' TurboTap

Matt Younkle Case: Background Material

A current UDM graduate student, Anita Bersie, went to school with Matt Younkle at the University of Wisconsin Madison. She provided professor Weaver with the lead to create this case study.

While a student at UW-M, Matt was frustrated by how slowly the beer line in the student union moved. He decided to do something about it by teaming with a few friends and entering into a creativity contest at UW-M. They won that contest, and went on to create Turbotap – a beer dispensing apparatus which combats the head producing effects of gravity and turbulence to quickly dispense perfect glasses/pitchers of beer with no waste. A variety of Turbotaps are shown in Figure 3.



Figure 3. Turbotaps

This case study provides some of the story behind Turbotap. When the authors spoke to Matt Younkle over the summer, he was planning his imminent retirement to the Bahamas.

Matt Younkle Case: Outline of Case Content

To convey the nature of the case study presentation as much as possible without being able to include the video clips or detailed slides for size considerations, a rough content outline is provided below:

- Video: Watch CNBC story on Turbotap²
- Video: Matt Younkle discusses initial inspiration and winning school creativity competition
- Painstorming as an idea generation technique
- Video: Matt Younkle discusses raising money for Turbotap
- Video: Matt Younkle describes the fluid mechanics principles of how Turbotap works
- Images of the product itself and some of the figures from their patent illustrating the inner geometry
- Video: Matt Younkle describes their attempts to use modeling and simulation, ultimately to resort to iterative testing
- Video: Matt Younkle describes the business model (Turbotap is leased rather than sold)
- Video: Matt Younkle describes the manufacturing approach
- Video: Matt Younkle discusses invention vs entrepreneurship
- Video: Matt Younkle discusses risk from his perspective as an entrepreneur
- Video: Matt Younkle discusses how engineers are in the driver's seat of entrepreneurship and that leadership, creativity, and communication skills are vital as an engineer

Matt Younkle Case: Course Integration

This case study is integrated into the fluid mechanics course at UDM. Since one of the key functional attributes of this product involves maintaining laminar flow during the dispensing of beer, students are asked to do a homework assignment comparing the Reynold's number of several possible nozzle architectures in comparison to a single circular nozzle.

Pedagogical Content Map of Cases

Pedagogically, the technical entrepreneurship case studies at UDM can be thought of as bits and pieces of the desired entrepreneurship content spread across the technical courses into which the case studies are embedded. As such, it is essential to maintain a big-picture understanding of which content is covered in which cases. This can facilitate thorough coverage by the cases taken collectively while minimizing redundancies. Of course, not all cases will be received by every student, and not all students will see the case studies they do see in the same order, so some overlap/redundancy is reasonable – particularly on many of the basics of entrepreneurship.

In order to keep track of the knowledge areas covered by each of our case studies and the collective set of case studies, we have adopted the hierarchical model of entrepreneurship content presented by PUI-eship, a web-based collaboration area for Institutionalizing Entrepreneurship at Primarily Undergraduate Institutions (PUIs). The content matrix available at PUI-eship³ was taken and each case study has been mapped onto that matrix to indicate which knowledge areas are covered. Given the brevity of these cases, most knowledge areas are covered only at an introductory level, with a few topics perhaps receiving a medium level of coverage. The content mapping for the cases is given in Appendix B.

Student Reaction to the Cases

After each case presentation, the students have been asked to discuss their opinions on the case study and its effectiveness toward developing the entrepreneurial mindset in the students. The response has been overwhelmingly positive, with numerous comments essentially saying how refreshing and inspiring it is to see what someone can do with the course materials they are currently learning. Many students have also expressed a desire for much more such content, and instructors have noticed a heavy level of engagement by students who sometimes seem less than fully attentive in class. When the students are asked if they would like to see more such entrepreneurship cases embedded into their classes, the consensus is strongly in favor of that. These cases seem particularly valuable in attracting and retaining underrepresented students given that UDM prides itself on diversity and since there are research findings that suggest that underrepresented students respond well to a more applied approach to engineering studies. The authors plan a more structured student survey on the cases for the near future to supplement the traditional course evaluations.

Conclusions and Future Work

The authors feel that the technical entrepreneurship case study approach is one of the key pieces in our attempts at UDM to broadly instill the entrepreneurial mindset in as many students *and faculty* as possible. Several more case studies are to be developed as part of a recently received KEEN Phase II grant from the Kern Foundation. The process of preparing a proposal for a minor in entrepreneurship is also underway.

References

1. <http://www.whisprwave.com/>
2. CNBC video at <http://video.msn.com/?mkt=en-us&vid=6ecedcac-00e6-466e-a2c0-74bc3b0f8d4b>
3. <http://www.pui-eship.org/>
4. www.somanetics.com

Appendix A
Student Handout for the Ray Gunn Case Study

UDM Technical Entrepreneurship Case Study: Ray Gunn
Development supported by the Kern Entrepreneurship Education Network (KEEN)
Developed by Jonathan Weaver and Arun Aakaluashok
April 2007

Background

This case study is one of several being developed as part of the KEEN initiatives at UDM. The purpose of these case studies is to illustrate how entrepreneurs have capitalized on their knowledge of specific technical topics such as those being covered in the course you are currently taking. At UDM, this case study is planned for integration into the Mechanical Measurements (Instrumentation) course; other institutions may find the content perfectly suitable for embedding into alternative courses (signal processing, biomedical engineering or physics for example – not to mention any course in entrepreneurship).

Introduction

This case study is about a man named Raymond (Ray) Gunn. Ray Gunn has spent his career acting as the principal financial and strategic architect to build concept technologies into commercialized ventures/companies. He has led ten teams through their formation, funding, growth, and ultimate sale or Initial Public Offering (IPO). Additional information about Ray Gunn's background can be found at http://www.wingspanco.com/wst_page2.html.

Somanetics and Clarity are two of the companies resulting from Ray Gunn's efforts. In order to contain the scope of this case study, the focus will be on these two ventures.

Somanetics

Somanetics develops, manufactures and markets the INVOS Cerebral Oximeter, the only noninvasive patient monitoring system that continuously monitors changes in the blood oxygen levels in the brain commercially available in the U.S.

Prior to the in-class case study presentation, learn more about Somanetics' INVOS Cerebral Oximeter by visiting www.somanetics.com (make sure you visit www.somanetics.com/invos.htm and www.somanetics.com/invos_principles.htm) and developing answers to the following questions:

1. What is the basic principle of operation of the INVOS Cerebral Oximeter?
2. Who is the target market?
3. What was the purpose of the clinical research and was it necessary?
4. What things which we have learned in this course relate to this product?
5. What are Soma Sensors and do you think it makes business sense for Somanetics to make them a disposable commodity?

Optional: Review Somanetics' U.S. Patent Number 5,902,235 entitled *Optical Cerebral Oximeter*. (To do so, go to <http://patft.uspto.gov/netahtml/PTO/search-bool.html> and enter *Somanetics* for **Term 1**, choose *Assignee Name* for **Field 1** and click on search; a list of Somanetics' patents will appear allowing you to click on the above patent).

Clarity Technologies

Clarity Technologies is a leading provider of software and services for echo and background noise cancellation in voice-based products. Its Clear Voice Capture technology (CVC) is their principal product; it has found widespread application in a variety of wireless headsets, cell phones, and automotive hands free systems. In March of 2005, Clarity Technologies was acquired by CSR plc (LSE: CSR.L), ("CSR") a wireless solutions provider and leading supplier of Bluetooth technology.

Some of the story behind Clarity's CVC will come out in the presentation of the case. In order to familiarize yourself with Clarity and CVC before the in-class case presentation, visit <http://www.csr.com/products/cvc.htm> to learn a bit more.

Appendix B

Content Area Matrix: UDM KEEN Case Study Coverage (matrix based off of PUI matrix online at <http://melchior.muhsen.edu/twiki/bin/view/PUIship/ContentAreasMatrix>) (last update 20071003)

Note: PUI Matrix breaks out each item to three depth levels (Intro, Medium, or Advanced). At this point, all our coverage is felt to be at the intro level.

Legend: JS = Jonathan Smith Case, RG = Ray Gunn Case, and MY = Matt Younkle Case

Topic	Sub-topic	Sub-subtopic	Case	
Background	what is eship		JS,RG,MY	
	self-assessment			
	role models			
	successes/failures		JS	
	history of eship			
	eship philosophies		social entrepreneurship	
			bottom-line driven	
			academic entrepreneurship	
			intrepreneurship	
			Lifestyle	
Idea generation	creativity		RG	
	brainstorming			
Planning	opportunity evaluation		RG,MY	
	initial business planning	concept plan		
		business plan		
		Stakeholders		
	ongoing strategic planning			
	exit strategy		JS	
	product life cycle		JS	
	forecasting			
	economic modeling		RG	
Stagegate model			JS	
Project management	scheduling			
	logistics			
	time management			
	staffing/human resources		RG, MY	
	leadership delegation			
Legal	business/tax legal structure	S,C,sole,LLC,LLP,LTD		
		nonprofit: 501c3, etc.		
	Intellectual property	Copyrights		
		Trademarks		
		trade secrets		
		utility and design patents	RG, MY	
	provisional patents			

Topic	Sub-topic	Sub-subtopic	Case
		nondisclosure agreements	
		noncompete agreements	
	regulatory issues		
	incorporation		
	liability	Insurance	
		product-liability	
		personal-professional liability	
		corporate liability	
	contracts		
	labor laws		
	international business law		
Economics	micro economics		
	macro economics		
	currency		
	import/export		
	tariffs/trade		
Financial	accounting	balance sheets	
		cash-flow statements	
		payables/receivables	
	start-up finance	Bootstrapping	JS, MY
		angel capital	RG
	growth finance	venture capital	RG
	taxes		
	development cost estimation		
	pricing models		
	financial statements and reporting		
	stock	stock types: public private	
International business	culture		
	products		
Corporate organization and culture	small business		
	family business		JS
	corporate (S,C, ...)		
	consulting		
	lifestyle		
	non-profit		
Technology			

Topic	Sub-topic	Sub-subtopic	Case
Human resources	staffing planning		
	personnel manuals		
	benefits		
	hiring procedures		
	evaluation strategies		
	training and prof. dev. writing job descriptions		
	compensation		
	pensions		
	liability		
Market research	market studies		RG
	focus groups		RG
	survey generation		
	data analysis		
	industry analysis		
	competitive analysis		RG
Marketing	niche advantage		RG
	competitive advantage		MY
	product life cycle		
	market identification/target market		MY
	market capacity		
	profit potential		MY
	branding and logo		
	promotion		
	product identification		
	economies of scale		
	franchising		
Sales			
Teaming	leadership		RG
	trust		
	team dynamics		JS
	team communication		
Ethics			
	inventory control		
	design for manufacturing		JS
	staffing		
	logistics		
	statistical process control/QC certifications (ISO,etc)		
supply chain management			

Topic	Sub-topic	Sub-subtopic	Case
Risk analysis	decision making		
	risk identification		
Professional skills	oral communication		
	written communication		
	leadership		
	conflict management		
	emotional intelligence		
	etiquette		
	attire/comportment		
	networking		
	negotiation		
	interviewing		
	resume building		
	attire		
	risk taking		
	failure acceptance		
Distribution			
Design and development	specifications		
	concept generation		MY
	concept selection		MY
	decision making		
Management and governance			
Opportunity identification			