ADVANCED NANOTECHNOLOGY ENTREPRENEURIAL EDUCATION

Christopher C. Ibeh
Pittsburg State University (PSU), Pittsburg, KS 66762

Abstract

Development of the "Advanced Nanotechnology Entrepreneurship" course is an ongoing project at PSU that is part of a three course entrepreneurship series funded through an NCIIA (National Collegiate Inventors and Innovators Alliance) grant. The course focuses on product design and development with emphases on the entrepreneurial elements of team-based design, benchmarking, design optimization, on-time market entry, life cycle cost analysis [LCCA], data mining, patents, safety and ethics. The course is functionalized with projects. A 9.3 participants' satisfaction index indicates that course is desirable.

Introduction

A paper entitled: "Nanocomposites Entrepreneurial Education" presented at SPE-ANTEC 2008[1], indicated CNCMM's entrepreneurial education initiative and efforts to develop a nanotechnology entrepreneurship three course series at Pittsburg State University. This paper discusses the second of this course series. The course focuses on product design and development with emphases on the entrepreneurial elements of team-based design, benchmarking for competiveness and cost-effectiveness, specifications, design optimization, on-time market entry, life cycle cost analysis [LCCA], data mining, patenting, safety, ethics, and role of government regulations. Course activities also include the nanoresearch, ethics, software and "ECo-TIES" [Environmentally Compliant and Transformative, Integrated Energy System] projects.

This course presents a detailed excursion of the product development process from concept generation to design for manufacturing, and builds on the foundational fundamentals of the first of the course series[1]. Emphases are on product definition, early concept development, visual reasoning and engineering design. Students work in cross-disciplinary teams, and projects may be provided by corporate partners/sponsors. Participants deal with real problems of significant issue to the sponsor, and these typically involve engineering, finance, accounting, and marketing. These teams work with program faculty advisors and representatives of the sponsor-corporations to develop detailed, implementable solutions that enhance productivity and ROI.

The objectives of the advanced nanotechnology entrepreneurship course at PSU are to: utilize the product design and development process in inculcating in the aspiring entrepreneur the importance of entrepreneurial decision making skills, and the need for ethical and environmentally-friendly leadership practices.

This paper discusses the efforts and results of the design, development and delivery of the advanced nanotechnology entrepreneurship course. A search of the literature indicates[1-3]that this course is fairly unique with its combination of nanotechnology and entrepreneurial elements. Literature further indicates that benchmarking, a benchmark of this course, is an industry trend, and a must-practice for market leadership, profitability and sustainability. Furthermore, the

ECo-TIES and nano-research projects are cutting edge and unique to CNCMM; ECo-TIES addresses the problems associated with the currently-in-use, fossil fuel-based power systems such as air pollution, environmental pollution from oil spills, global warming, dependence on imported oil, lack of sustainability and homeland security issues.

The course is introduced via such concepts as "Productivity /S-Curve" and market entry strategies. Course modules include such entrepreneurship elements as: product design and development, LCCA -product design and development for the environment, entrepreneurial data mining, ethics and safety, intellectual property, Nanoresearch, sensitivity and breakeven analyses.

"Productivity/S-Curve:" Market Entry Strategies

The concept of "Corporate Darwinism"[1] propounds the theory that even the most successful companies are susceptible to competition, and that opportunities exist for "start-ups." Start-ups" with the right combination of product, strategy and business plan implementation can be competitive. The S-Curve (Figure 1)[4-7] relates to technology adoption rate, and can be utilized to represent a corporation's productivity or market share or product's life cycle (ordinate) with time or effort (abscissa). Three distinct phases of the S-Curve are discernable: A, Starting Friction, has a negative productivity slope mostly due to entry costs from R&D and other capital investments, B, "RICH" or "Sweet Spot" has a positive slope, and is characterized by enhanced productivity and profitability, and C, "Diminishing Returns" begins with peaking of B. C is characterized by a negative slope as A but represents the fact that the results or productivity does not match expended efforts. The inflection point between phases A and B signify a point for fruitful entry of the market for the product of interest. Phase C suggests market exit or re-structuring of product's marketing profile.

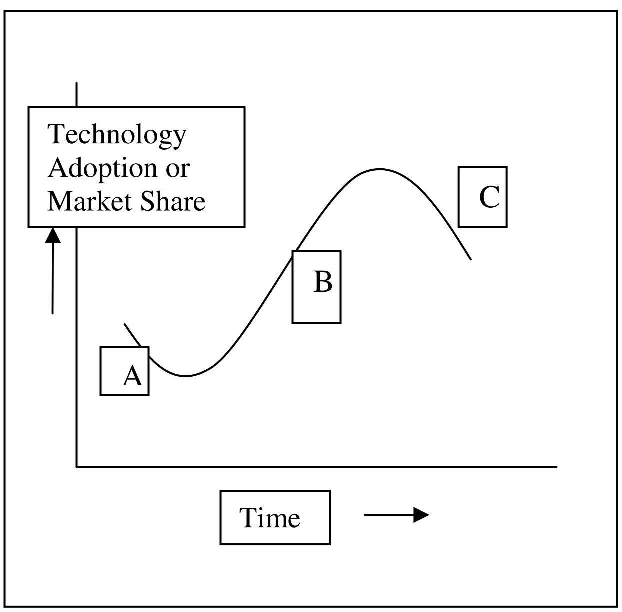


Figure 1: The S-Curve

Product Design and Development (PD&D)

PD&D is the core module of this course. Course being interdisciplinary (Table 1 – Course Participants' Demographics), foundational introduction to PD&D is made via relevant ABET criteria such as c, d, e, g, h, j; these encompass the ability to: design a system, component or process to meet desired needs, function on multidisciplinary teams, identify, formulate and solve scientific, engineering and technological problems, communicate effectively**,** understand the implication of scientific, engineering and technological solutions in a global context**,** know of contemporary issues, etc. Understanding the design process and problem solving are part of the course objectives. Sustainability and green engineering are contemporary issues, and are accounted for in the nano-research and ECo-TIES projects.

Table 1: Course Participants Demographics - Advanced Nanotechnology Entrepreneurship

Student	Classification	Major	Research Projects
C.B. $#	Senior Plastics ETECH	Plastics ETECH	* LCCA *ECo-TIES
N. Z. %#^	Senior Physics/Chemistry	Plastics ETECH	* Panel Fab. * ECo-TIES
T. M. $#	Senior Plastics ETECH	Plastics ETECH	* DOE * ECo-TIES
I. C @#^.	Graduate Civil Engineering	Masters ETECH	* Gel Fiber * ECo-TIES
C. O. @&^	Graduate Computer Science	MBA	* CART * ECo-TIES
X. S %&^.	Graduate Chemistry	Masters Chemistry	* Kinetics – Vinyl Ester Nanocomposites * ECo-TIES
J. M @&^.	Graduate Plastics ETECH	MBA	* DOE * ECo-TIES
A. G. @#^	Graduate Chemistry	Masters Chemistry	*Nanosensors *ECo-TIES

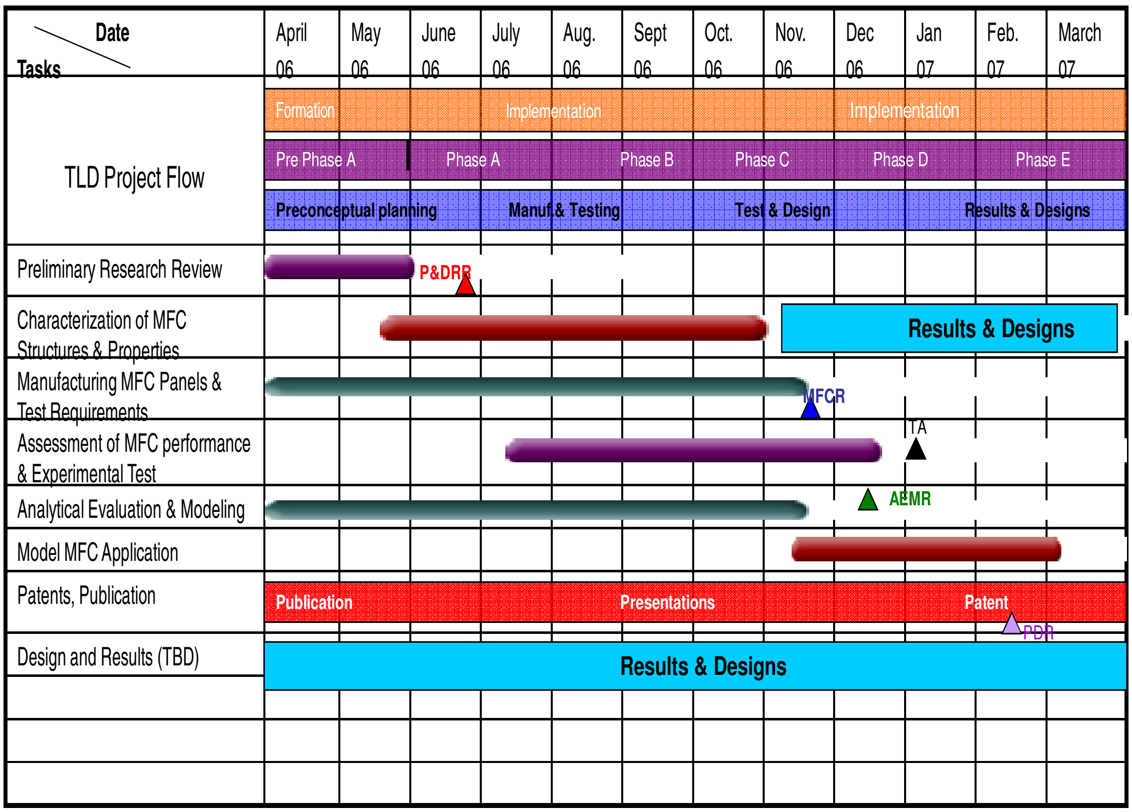
* ECo-TIES – environmentally compliant and transformative, integrated energy system
* LCCA – Life Cycle Cost Analysis
*ETECH – Engineering Technology
* DOE – Design of Experiments
* CART – Classification and Regression Tree
$= US Citizen; &=Female; %=Chinese; @=African; #=Male; ^=International

Product design and development (PD&D) is discussed under the following key sub-headings: Project Planning – Gantt Chart, Product & Market Definition, PDD Benchmarking, PDD Specifications, Economic Analyses, Intellectual Property (IP), Safety and Ethics, Documentation, and Dissemination.

Project Planning – Gantt Chart

Tables 2 and 3 are examples of the Gantt chart. Popularity of the Gantt chart marginalizes the necessity of its discussion in this paper; a brief narrative is however attempted for conformity and technical correctness. The Gantt chart is the industry standard format for representation of

Table 2: UNO MFC Research Plan -- Multifunctional Materials For Naval Structures Project .. A CNCMM/UNO/NCAT-CCMR Partnership



P&DRR – Publications & Draft Requirements Review

MFC – Functionally Graded Materials Manufacturing Review

TA - Test Assessments

AEMR – Analytical Evaluation & Modeling Review

PDR – Preliminary Design Review

a project's implementation timeline or scheduling. Regardless of its form, it must correctly identify the major and critical elements of the particular project under consideration, and also the duration or time needed to effectively implement the given task or activity. A Gantt chart reflects the flow of activities or tasks necessary to successfully accomplish a project, and how the different tasks or activities are inter-linked. The Gantt chart, invented in 1910 by Henry Gantt, a mechanical engineer, is a "stand alone," "bird's eye view" of a project's scheduling. It is "stand alone" such that a professional or expert can interpret it into a complete and finished product. A

Gantt chart can be updated periodically to distinguish already accomplished elements and project's aspects that still need to be implemented; use of blue colored line(s) in Table 3 distinguishes Task 1: Pres-design and Team Identification, as already accomplished.

Table 3: ECo-TIES Work Plan and Outcomes (Project Timeline)

Project Activities	2008	2009 Quarters				2010 Quarters			
	IV	I	II	III	IV	I	II	III	IV
1. Pre-design and Team Identification	→	→							
2. Grant Application/ Revision and Project Team Assembly	→	→	→						
3. Identification and Sourcing of ECo-TIES components, materials, supplies, & suppliers		→	→	→					
4. Verification of Pre-design and design refinement			→	→					
5. Prototype Production & Assembly				→	→	→			
6. Presentation of Prototype @ NCIIA Conference						→	→		
7. Demonstration of Prototype to Prospective Sponsors, Partners and Customers						→	→	→	
8. Preparation of Business and Commercialization Plan			→	→	→	→	→	→	
9. Preparation of Project Report to NCIIA			→	→	→	→	→	→	

Several cost-free, online tutorial and software sources exist for the Gantt chart, and a few are provided below for ease of reading.

- Excel Gantt Chart Template (Download a Gantt Chart template for Microsoft® Excel® or OpenOffice Calc) http://www.vertex42.com/ExcelTemplates/excel-gantt-chart.html?xls

- Gantt chart via Microsoft Excel (video tutorial) **http://www.youtube.com/watch?v=CW_wGSFavTc&feature=channel_page**

- **http://www.smartdraw.com/downloads/index.htm?WT.svl=link01**

Product and Market Definition: Market Analysis

Product/Market definition and identification are crucial components of the PD&D process, and need to occur at the initial phase of the process as they are at the core of a company's strategy to respond to customer/market needs and opportunities[8]. Inadequate product/market definition and identification is major source of failure for new ventures. It is advisable that product developers incorporate market analysis into the development process, and to realize the importance of the business and financial plans. Market analysis incorporates such elements as customer profiling, product pricing, product diffusion rate, scheduling and competition. Market analysis is accomplished via use of sophisticated sampling and testing techniques available from marketing agencies per marketing requirements specification (MRS). MRS attempts to ascertain the revenue yielding potential of a proposed product. Oftentimes, a variety or a combination of sampling techniques[9-11] such as conjoint analysis, internet surveys, Focus groups and face-to-face interviews are utilized to garner data about product requirements and customer preferences. A good market analysis identifies and segments groups that influence purchasing decision on the product under study. These product requirements are translated into real-time design specifications that enable the achievement of a product's functional and performance objectives.

Product Design & Development: Benchmarking

Benchmarking is a strategic industry and management "Best Practices" trend, and its origin is attributed to Zerox Corp. It is a process of identifying strengths and weaknesses (assets and liabilities) of a given unit, and the comparison with global industry leaders and the competition[7]. Benchmarking is analogous to the surveyor's reference point from which heights and distances are measured. It involves a proactive and formalized search for change by which an organization implements an "environmental scan"[1] to study, understand and adopt the best-available techniques and technologies.

The benchmarking[12] process comprises of five major components [and twelve distinct stages]: planning, analysis, integration, implementation and maturity [Figure 2]. Data collection includes information on product(s) and related products, functions a product performs, targeted market segment(s), etc. Typical sources of information and data include but not limited to libraries, Thomas Register [http://www.thomasregister.com], National Bureau of Standards [NBS](now NIST), Census of Manufacturers by the US Department of Commerce, Market Share Reporter, internet, Consumer Reports Magazine, Patents – www.patents.ibm.com/ [In 2007, IBM, a globally recognized computer industry leader received 3,125 U.S. patents from the USPTO], Moody's Industry Review, Trade Magazines, etc. The Thomas Register is the "yellow pages" of the manufacturing and related industries. The NBS is a US Government publication with information and data on national labor rates for most countries, and is a good source for the competition's manufacturing costs. Census of Manufacturers is carried out every 5 years; information and data provided include employment statistics, capital expenditure, payrolls, manufacturing costs, production and shipment. The Market Share Reporter is a yearly publication by the International Thomson Publishers that provides market share reports of corporations, organizations and brands.

Determination of current performance status versus desired status is done as per the “GAP’ analysis. The “GAP” Analysis is the industry recognized protocol for performance status evaluation.

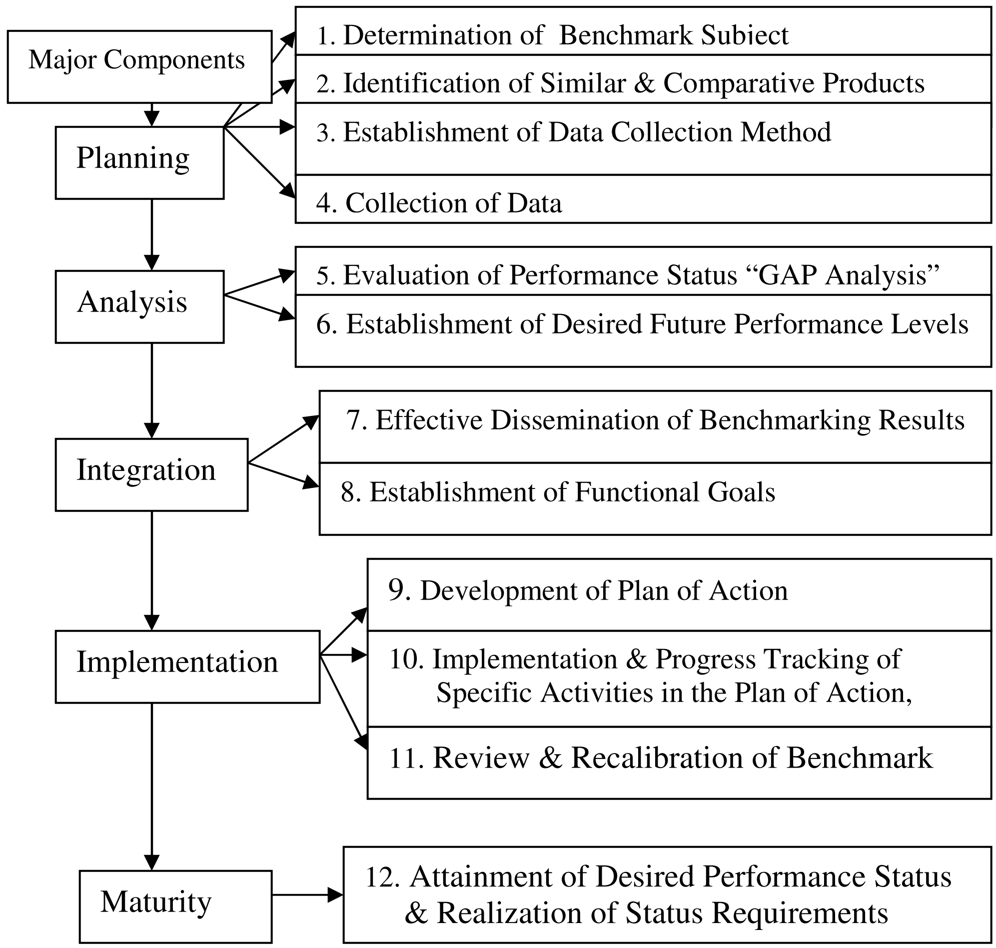


Figure 2: The Five Major Components and Twelve Stages of the Benchmarking Process.

Product Design & Development: Specifications

The course lecture format is as per the “Institution of Production Engineers (IPE) of Britain.” Specification serves as the major reference for the PD&D activity and is a dynamic document that changes with progress of the design and development activities. It provides realistic constraints on the PD&D process, and is typically preceded by literature review, market research, patent searching and benchmarking. IPE’s guidelines are based on 28 elements such as performance, environment, service life [30+ years for naval ship hulls], competition, desired product cost, standards or specification scales, maintenance & logistics, etc.

Economics: Sensitivity & Breakeven Analyses

The needs for entrepreneurial market research, business planning and financial planning[1] "boil down to" economics and measures of profitability such as breakeven analysis and return on investment (ROI). Entrepreneurial breakeven point is attained when total income equals total expenditure, and income (sales) beyond the breakeven point results in PROFIT. Profit is a desirable condition for entrepreneurial sustainability[13-14]. "Total sales" is as per equation 1.

$$R = Q \cdot P \qquad (1)$$

R is the total sales or revenue, Q is the number of units sold and P is price per unit. Total cost is as per equation 2.

$$TC = FC + VC \qquad (2)$$

TC is the total cost, FC is the total fixed costs and VC is variable costs.

$$R = TC \qquad (3)$$

Equation 3 represents the "breakeven point" condition.

$$Q.P = FC + VC \qquad (4)$$

Eq. 4 results from substituting R from Eq. 1 into Eq. 2.

Knowing the total costs of a given venture or product, equation 4 facilitates determination of desired price per unit and number of units to be sold for breakeven and profitability. With determination of profitability, it is possible to evaluate the return on investment (ROI) and return on equity (ROE) as per equations 5 and 6 respectively.

$$ROI = \text{Net Income} / \text{Investment} \qquad (5)$$

$$ROE = \text{Net Income} / \text{Owners' Equity} \qquad (6)$$

Owners' equity is the sum of venture's original equity and retained earnings.

In essence, it is important for a start-up or any corporation for that matter to have very reasonable and successful revenue and profit models. Estimations of actual revenue must take into account discounts, rebates and returns. Discounts, rebates and returns provide customer "value," are sources of customer "good will" and are added forms of advertisement, and are considered as part of "costs of doing business." A good revenue model strives to minimize costs as costs of doing business tend to be product or business-specific. The ability to reduce costs is a technical capability and is product-specific, and should feature prominently in any company that strives for long term viability and success. The ability to minimize costs provides a company the leverage to achieve desired profit margins, and the associated long term viability and entrepreneurial sustainability.

Typically "costs" include but not limited to: employee salaries, raw materials, equipment purchase/lease, facilities, R & D (mostly for established entities), advertisement and marketing, communication, office utilities and supplies, etc. On a product basis, the total cost is equal to the sum of the manufacturing costs, indirect plant costs and management/administrative costs.
In general and as already stated via equation 2, costs are distinguished mainly as Fixed Costs and Variable Costs.

The Fixed Costs comprise of three major components:

a. Indirect Costs,
b. Managerial Expenditures, and
c. Sales & Marketing Expenditures

The indirect costs are the (i). Investment costs such as depreciation, interest, property taxes, insurance, and (ii). Overhead costs such as engineering/technical services, non-technical services (office personnel, security, medical, etc.), equipment rental and general supplies. The Managerial Expenditures are costs associated with personnel shares and legal shares whereas the Sales & Marketing Expenditures include the technical service staff, storage/delivery and sales personnel costs.

The Variable Costs include such items as materials, labor with fringe benefits, direct supervision of labor, utilities, maintenance, quality control, packaging, scrap/spoilage losses, patent & royalty payments, etc.

The IRS (Internal Revenue Service) has very specific definitions of costs that mirror the above definition. It is the contention of this author that the IRS definition of costs is the frame of reference for determining "Total Costs."

Regardless of what approach is used, it is not surprising that materials costs feature very prominently in the determination of "Total Costs." In some industries, materials costs can be as high as 50 – 60% of the total costs. Direct materials costs plus labor costs [variables costs item 1 and 2] yields the Prime Cost. The Prime Cost plus Indirect Costs such as utility, maintenance supplies and plant indirect labor, yields Plant Cost. The Plant Cost plus General Fixed Expenditures such as engineering, depreciation, office staff, purchasing, staff etc. yields Manufacturing Cost. The Manufacturing Cost plus Sales Expenditure yields the Total Cost. The Total Cost plus Desired Profit yields Selling Price.

Figure 3 shows a modified S-Curve that is representative of the profit model. The pre-market phase, A is the R&D/Prototyping stage, and is characterized by an initial zero profit that is followed by an expected financial loss due to the associated non-commercial type activities. The A phase is followed by the "RICH" B phase that is characterized by commercial-type activities such as market entry, competiveness and high profit margins. The market matures at C; a point that is followed by diminishing profit margins. The profit model of Figure 3 indicates that these product market stages are quantifiable, and are determined and influenced by the strategies and activities of the particular company or product line. Hence, the need for entrepreneurial strategies that entail successful revenue and profit models.

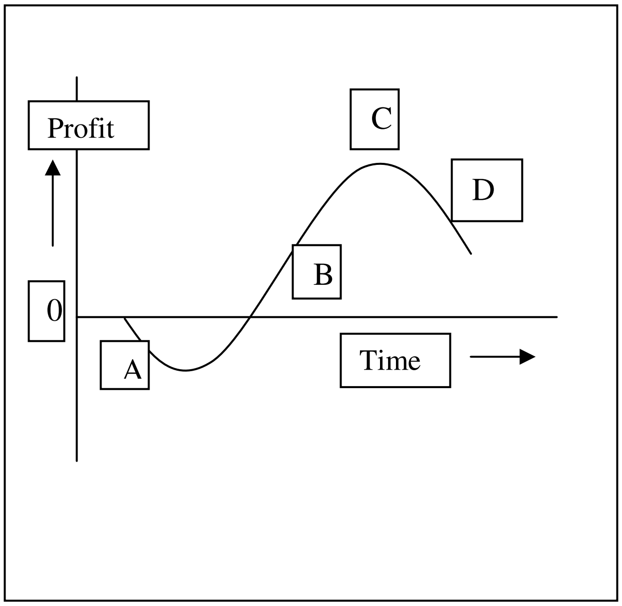


Figure 3: Profit Model: A Modified S-Curve

Safety, Ethics and Intellectual Property

This course being part of the CNCMM program, there are emphases on safety, ethics and intellectual property. CNCMM has a nano-safety initiative[10]. One of the first course activities is an organized workshop on safety and ethics. The school's safety officer is invited to direct this workshop, and the students are apprised of the school and state's safety requirements. Health and environmental effects of nanoparticles are examined and discussed, and the necessary safety precautions and ethical issues are stated. There is need to create safety and ethics policies that will help in mitigating the possible harmful effects of nanotechnology on society and the environment. Program participants typically engage in nanoresearch, and are assigned specific research and ethics projects. Participants' research and reports can be viewed via the CNCMM website at the URL: www.pittstate.edu/reuret/**research**.htm
http://www.pittstate.edu/reuret/**ethics**.html

Documentation and Dissemination

Documentation and dissemination are key components of project implementation. Sponsoring agencies such as the NSF, ONR, NCIIA, etc require that funded projects disseminate research findings via journal, conference and workshop publications and presentations to facilitate exchange of ideas and innovativeness. The advanced nanotechnology entrepreneurial education course is designed and formatted such that course participants present their project and research findings in the class environment in the form of reports and oral presentations. The CUES-AM[14-15] report writing format is the course's adopted writing and reporting style. The course's writing and reporting activities facilitate the thesis efforts of the graduate members, and enhance the participants' overall ability for publishable research[2-3, 16-18].

Results, Course Evaluation and Discussion

Development of the advanced nanotechnology entrepreneurial education course is an ongoing project. The course was delivered to eight students during the 2008 summer semester, and it was made practical by use of the nano-research, ethics, software and ECo-TIES projects. Students designed and developed a prototype of an environmentally-compliant and transformative, integrated energy system involving the use of solar energy and wind energy to generate hydrogen from water, and the use of generated hydrogen to power a fuel cell. Also, the students developed business and financial plans for this endeavor, and participated in the development and submittal of an NCIIA proposal based on this project. These efforts involved market research and patent searching. Appendix 1 has the assessment data for this course. Data of Appendix 1 indicates a true satisfaction index of 0.93 or excellent[15] performance for this course. The average values of 9.4, 9.0, 9.3, 9.4 and 9.3 for the usefulness, interest, comprehensiveness, validity and efficacy factors respectively, indicate a participants' consensus that the course is of interest, meaningful and desirable.

Conclusion

This paper demonstrates the successful development and delivery of the course entitled: "Advanced Nanotechnology Entrepreneurship" at Pittsburg State University. Student participants' activities and the results of these activities affirm the need for such a course at PSU and other institutions. Productivity is the economy's backbone. Entrepreneurship and the development of entrepreneurial skills enhance the ability to leverage knowledge and ideas into productivity. The course's interdisciplinary format recognizes the need for collaborations across disciplines, and the premise that innovations occur at the interface of disciplines.

Acknowledgment

CNCMM is an ONR-sponsored research and education center at PSU. PSU's support of CNCMM, and NCIIA's funding for the entrepreneurship course series are very much appreciated.

References

1. C.C. Ibeh, M. Bubacz, "Nanocomposites Entrepreneurial Education," *SPE-ANTEC*, Milwaukee, WI, May 4-8 (2008).
2. O. Onovo, K. Golla, C. Ibeh, "NanoSafety Education," *SPE-GPEC,* Student Poster #3, March 10-12, Orlando, FL (2008).
3. S. Bietto, Staff Quarterly Report, Center for Nanocomposites & Multifunctional Materials (2007).
4. C. Christensen, *The Innovator's Dilemma,* Harvard Business School Press (1997).
5. C. Christensen, M. Raynor, E. Michael, "The Innovator's Solution," *Harvard Business School Press* (2003).
6. M. Nieto, "Performance analysis of Technology Using The S-Curve Model: The Case of Digital Signal Processing Technologies," *Technovation,* **18**, Issues 6-7, pp. 439 Jan. (1998).
7. R.T. Niemeyer, "The S-Curve," *EU Reporter*, October 20 (2008).
8. R. G. Cooper, Winning at New Products, *Addison-Wesley Publ. Co*., Reading, MA, (1986).
9. N. Kularatna, "Marketing Requirements Specification," Electronic Circuit Design: From Concept to Implementation, CRC Press, 2008, Pages 60 – 61.
10. K. Crow, "Product Definition," http://www.npd-solutions.com/pdef.html (accessed online August 13, 2009)
11. R. Krieg, "Impact of structured product definition on market success," International Journal of Quality & Reliability Management, 2004, Vol. 21, Issue 9, Pages 991 1002.
12. R.C. Camp, Benchmarking: "The Search for Industry Best Practices That Lead to Superior Performance – Part III," *Quality Progress*, **22** No.3, pp 76-82 (1989).
13. R. Dorf, T. Byers, *Technology Ventures*, McGraw-Hill, Second Edition, pp. 355-399 (2008).
14. J.L. Nesheim, *High Tech Start Up*, The Free Press, Edition, pp. 68 - 78 (2000).
15. C.C. Ibeh, "CUES-AM Online: A Program Assessment Protocol," *NCIIA,* pp 225 - 233 March (2006) http://www.nciia.net/conf_06/papers/pdf/ibeh.pdf
16. O. B. Onovo, A. Beyle, C. C. Ibeh, "Mechanical Properties of Syntactic Foams," *Society of Plastics Engineers-Annual Technical Conference* (ANTEC), May 4-8, 2008.
17. N. Zhou, A. Beyle, C. C. Ibeh, "Thermal Viscoelastic Analysis of 3D Fabric Nanocomposites," *Advanced Materials Research* Vols. 47-50 (2008) pp 1133-1136.
18. Xue Sha, "Effects of Sonication on the Kinetics and Mechanical Properties of Vinyl Ester Nanocomposites," *MS Thesis*, Department of Chemistry, Pittsburg State University, Dec. 2008.

Key Words: Nanocomposites, entrepreneurial, education, course, productivity curve, benchmarking, satisfaction index, market entry strategy.

Biographical Information

CHRISTOPHER C. IBEH

Dr. Chris Ibeh is a professor of plastics engineering technology at Pittsburg State University, KS. He is the director of the Center for Nanocomposites and Multifunctional Materials (CNCMM). Professor Ibeh has a doctorate from the department of chemical engineering at Louisiana Tech University, and MS and BS degrees in Natural Gas Engineering from Texas A & M University, Kingsville, Texas.

"Appendix" 1: CUES EKE [Essential Knowledge Elements] ADVANCED NANOTECHNOLOGY ENTREPRENEURSHIP COURSE –summer08	EKE Factors						
	Usefulness 1 to 10	**Interest** 1 to 10	**Comprehensiveness** 1 to 10	**Difficulty** 1 to 10	**Validity** 1 to 10	**Efficacy** 1 to 10	**I_s-Average (as needed)**
Topics Covered:							
* Introduction	9.5	10.0	8.5	3.5	9.5	10.0	
-- Productivity/S-Curve	8.7	8.8	8.7	1.7	8.3	9.0	
-- DISC Test	9.7	9.7	9.8	3.6	9.3	9.2	
-- ABET Criteria	9.0	8.7	8.6	2.1	9.0	9.0	
* Product Design & Development	10.0	10.0	10.0	1.0	10.0	9.5	
-- Product/Market Definition	9.8	9.3	9.0	3.3	9.0	9.0	
-- Benchmarking	9.3	9.3	9.0	3.0	9.3	9.0	
-- Specification	9.7	9.6	9.7	3.6	9.0	9.0	
-- Optimization & Simulation	9.3	9.7	9.4	2.8	9.3	9.4	
-- Business Plan	9.8	9.8	9.0	3.7	9.0	9.0	
-- Economics: ROI & Sensitivity Analysis	8.3	8.4	8.3	3.4	8.7	8.3	
* Projects	10.0	10.0	10.0	1.5	10.0	9.5	
-- NanoResearch	9.4	10.0	9.5	2.3	9.4	9.8	
-- ECo-TIES	10.0	9.4	9.0	3.0	9.6	9.7	
-- Software	8.0	7.9	7.8	4.1	8.3	7.4	
* Ethics & Safety	9.8	9.4	9.3	1.7	9.4	9.8	
* Intellectual Property	8.5	8.6	9.4	2.0	7.9	7.8	
* Field Trips	8.3	8.3	9.7	2.0	8.4	8.3	
* E-Clips Presented in Class	9.0	8.9	9.0	1.4	8.3	8.4	
* Overall impression of the course	9.3	9.4	9.0	3.2	9.4	9.3	
* Interaction inside the Class	10.0	10.0	9.8	1.0	9.6	9.8	
Average (for EKE Factors per column+)	**9.42**	**9.0**	**9.34**	**2.6**	**9.36**	**9.29**	

1. State your best element of this course: (1). Business plan; (2). Eco-TIES (3). Field Trips
2. State your worst element of this course: (1). E-Clips; (2). **Software**
3. How can this course be improved? (1). One Group Project & fewer individual (2). More Nanotechnology

CUES-AM Protocol and Interpretation

"CUES-AM, a major component of epistecybernetics, uses **expertly predetermined, site-specific** program attributes or essential knowledge elements (EKEs) in conjunction with the EKE Factors such as Efficacy, Validity, Comprehensiveness, Interest, Usefulness, and Difficulty to evaluate program participants' satisfaction level. The efficacy factor solicits the participant's level of proficiency on a particular EKE using a scale of 0 -10; 10 for maximum or excellent proficiency and 0 for minimal or very poor proficiency. Validity assesses the validity (0 – 10) of including a particular body of knowledge as represented by an EKE in the course. Comprehensiveness factor determines the level of thoroughness of instruction and delivery for an EKE. The Interest factor determines if the EKE is of interest to the student; interest is a widely recognized facilitator trait for entrepreneurship. The Difficulty factor evaluates the level of difficulty experienced by the student with a given EKE; this factor is analyzed as a negative contributor to the difficulty index ($\mathbf{I_D}$) and $\mathbf{I_{TS}}$, true satisfaction index. Satisfaction Index, $\mathbf{I_s}$ is the average of the EKE factors other than the difficulty factor divided by 10. $\mathbf{I_D}$ is the difficulty index. $\mathbf{I_D} = 0.2[(\mathbf{D_F} - 5) / 10] = 0.02(D_F - 5)$; D_F is the sum of all the EKE Difficulty Factors. The sum of ($\mathbf{I_D}$) and ($\mathbf{I_S}$) make up ($\mathbf{I_{TS}}$). Difficulty ratings of above 5.0 enhance the true satisfaction index. Online CUES-AM quantifies the participants EKE/EKE factor ratings into a true satisfaction index rating scale of (0.0 - 0.29) very poor to (0.90 – 1.0) excellent." For "Appendix" 1, $\mathbf{I_s}$ = 0.9282, and $\mathbf{I_{TS}}$ = 0.9274.