A Multidisciplinary Approach to Teaching Invention and Entrepreneuring

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Abstract

This paper describes the context, format, experiences, and outcome of three multidisciplinary team project-based pilot courses focused on teaching entrepreneurial skills and invention:

1. ME 490 "Invention and Entrepreneuring," co-taught by two professors (from engineering and business) at Michigan Tech for multidisciplinary students during fall quarter 1999.
2. N1D041 "Creative Problem Solving, Innovation and Entrepreneuring," a four-week intensive multidisciplinary course in a new one-year MSc in Entrepreneurship, Science and Technology program at the University of Nottingham during October 2000.
3. MODULE 12 "Entrepreneurship," a one-week condensed course in a University of Nottingham part-time MBA program co-taught by two business professors in Singapore for managers and engineers in business and industry in November 2000.

With special attention paid to teaching explicit thinking and creative problem solving skills and processes, as well as multidisciplinary and whole-brain team development, the student projects can result in viable invention – products or processes – that are patentable and can lead to the formation of a new business enterprise, as illustrated with some of the student project results. Students become excited about applying what they have learned and branch out into developing additional creative ideas and projects on their own.

I. Global Context, Philosophy and Motivation

Increasingly, industries all over the world are looking for people with entrepreneurial (or intra-preneurial) skills to gain a competitive advantage in today's global marketplace. The growth of knowledge-based companies has opened new opportunities for people who can solve problems creatively and know how to assess risks and be inventive and innovative. Governments and institutions of higher education are involved in cooperative ventures to address this need with a variety of approaches. Because of many institutional and administrative barriers, introducing new courses and recruiting students to enroll in these courses however has not been easy.

The objectives of three new courses developed and taught by the author in the past year are:

- Students learn teaming, communication, and lateral thinking skills as well as the creative problem solving process applied to invention and creating a new business.
- Students learn the practical aspects of the patenting and licensing process, how to protect and market their ideas, and how to develop a business plan. They learn how to access and use web-based and other resources for starting their enterprise and evaluate entrepreneurial ideas.
- The student-centered teaching occurs in a just-in-time format; thus individual topics are covered and resources identified as needed by the chosen team projects.
- Students gain an understanding of the organizational cultures that enhance innovation.

II. ME 490 "Invention and Entrepreneuring"

A pilot upper-level course funded by an NCIIA grant was team-taught in a 10-week course during the fall of 1999 by two professors at Michigan Technological University (Dr. Paul Nelson from Business Management and Dr. Edward Lumsdaine from Mechanical Engineering). The seven students in this class came up with three separate inventions. Also, one of these students learned how to protect an invention he had made previously. The students are now continuing work to develop their prototypes into marketable products. The format of the pilot course consisted of brief just-in-time seminars or lectures and extensive laboratory sessions. The students surprised the instructors by asking for additional class and lab time and most of all by the quality and commercial potential of their inventions. The main seminar topics are listed in Table 1 and the main steps of the invention process in Table 2.

Table 1 Main Seminar Topics—ME 490

1. Review of teamwork and communication principles for multidisciplinary E-teams[1].
2. Review of the creative problem solving process[1].
3. Creativity and invention applied to products and processes: case studies; steps and ground rules[1].
4. The product development process and entrepreneuring.
5. Patent searches and the patenting process; the inventor's log[6,16-19].
6. Advantages of licensing versus manufacturing: how to select and interview potential companies and the companies to approach.
7. Determining the customer's needs; prototyping; selling the invention or marketing a product; developing a business plan[1,20].
8. Additional topics as needed in the projects for just-in-time learning, such as talks by successful inventors and presentations by staff members of the university's intellectual properties office.
9. Evaluation of learning. Team presentation of invention to sponsors and stakeholders.

Table 2 Main Steps in the Invention Process—ME 490

1. Problem identification; customer survey; data analysis; definition of scope.
2. Idea generation using proven techniques. Each team can generate thirty to fifty or more ideas.
3. Creative idea evaluation using a list of criteria to forecast a potentially successful product:
   -- Easy to distribute
   -- Relatively simple technology
   -- Unique features
   -- Obvious benefits to consumers or customers of the product
   -- Product selling price at three to five times manufacturing cost
   -- Concept must have protection: patent, trademark, copyright, or license.
4. Feasibility study and optimization (Pugh method)[1,2]; economic analysis. Design and specifications[1].
5. Prototype construction and testing.
6. Design revision and evaluation. Potential for future development and marketing.
7. Final project reports (written and oral – including demonstration to interested audiences).

The three inventions from the pilot class, with potential market and current status, are:

- *Paging system for multimedia computers:*
  Subsequent work was needed for the "Pigeon" paging system to avoid infringing on existing patents. The concept is now being evaluated for technical feasibility and marketability by the Innovation Institute[15].

- *Novelty beer bottle opener with counter:*
  The idea started as a novelty bottle opener for alcoholic beverages. The student inventor has graduated and is now working in industry. He and his advisor have synthesized additional creative ideas to invent a complex product covering a wide range of applications. They are now in the process of applying for a provisional patent.
- *Strap-on tree stand bracket for hunters:*
  Manufacturing costs for four tree stand brackets and straps have been determined to be $7.20. With a projected selling price of $28.80, profits from Michigan sales alone are estimated at $300,000 by the fifth year. At the end of the course, the inventor initiated negotiations on a licensing agreement with an Ohio company.

III. N1D041 "Creative Problem Solving, Innovation and Entrepreneurship"

This course consisted of six 7-hour sessions and three 6-hour sessions of lectures and in-class exercises and project work over three weeks, supplemented with intensive out-of-class reading assignments, exercises, and project tasks (totaling approximately 90 hours). Ten-minute breaks were provided between topics, with one hour off for lunch. Each session topic listed in Tables 3a, 3b, and 3c was designed to last about 50 minutes. This introductory pilot course in a year-long program was well received by the 12 students who came from a broad array of fields, including engineering, management, and the social and biological sciences. This four-week intensive course was a strong motivator and encouraged the students to use or develop lateral thinking and teaming skills important for entrepreneuring and innovation.

Table 3a N1D041 Syllabus—Part 1: Creative Thinking

Session 1 — Motivation, Foundational Models and Thinking Skills	
1	Introductions and motivation, class objectives, diagnostic activities, visualization.
2	Joel Barker video *The Business of Paradigms* to gain an understanding of change.
3	Overcoming barriers and mental blocks to creative thinking.
4	The Herrmann model of brain dominance. Confidential HBDI results are returned.
5	Implications of the HBDI for communications. Paired "silent" drawing exercise.
6	Implications of the HBDI for teamwork. Teaming tools. Whole-brain sales ad exercise.
7	The creative problem solving model and metaphors. Creative thinking assignments.
Session 2 — Problem Definition	
8	Review of thinking exercises and Session 1 learning.
9	"Explorer" for discovering the context; "detective" for finding root causes of problems.
10	Finding promising problem areas for the team projects.
11	Explorer tools: preliminary patent search, the "don't sell me" game[7].
12	Detective tools: the list of questions and customer surveys. The Algona problem[7].
13	Project reporting and invention recording requirements. Tips for effective writing.
14	Teams select a project topic and define the problem—continued as homework assignment.
Session 3 — Idea Generation	
15	Teams present problem briefing. Synthesis of optimal problem definition statements.
16	Creativity, invention, innovation. Characteristics of innovators and entrepreneurs.
17	Adaptive and innovative ideas and entrepreneurs. Innovative organizational cultures.
18	"Artist" for idea generation: principles and techniques of brainstorming.
19	Inventive-thinking exercises from TRIZ.
20	Project application: Teams brainstorm ideas for solving their defined problem.

Table 3b N1D041 Syllabus—Part 2: Idea Evaluation

Session 4 — Mindsets for Idea Evaluation

21 Teams present problem briefings; development of improved problem definition statements.
22 "Engineer" for developing better ideas. What about "wild" ideas? Force-fitting exercise.
23 Teams generate fewer but higher-quality concepts through synthesis techniques.
24 "Judge" for ranking ideas and decision making.
25 Teams develop best solution alternatives from their "better" ideas.
26 Pugh method Round 1: review of method. Teams set up criteria and evaluation matrix.
27 Teams conduct the Pugh method Round 1 evaluation of their solutions.

Session 5 — Solution Optimization

28 Teams finalize their Round 2 concepts, improve the list of criteria, and set up the matrix.
29 Teams conduct the Pugh method Round 2 evaluation of improved concepts.
30 Teams attempt to distill a "best" concept from the Round 2 results.
31 Other tools for screening for best ideas.
32 Recognizing opportunities for innovation. Developing a mindset for innovation.
33 Testing ideas for opportunities in the marketplace.
34 Prototyping and economic decision making. Project application: develop superior concept.

Session 6 — Intellectual Property Protection (Patents) and Project Evaluation

35 Review of Session 5 work and out-of-class project development.
36 Protecting an invention through patents: UK and US patent laws. Patent searching.
37 The teams begin a patent search in the area(s) of their invention or project.
38 Peer contribution rating form. Tips on effective technical communication.
39 Sketching lab: Demonstration of complex sketching skills using the right brain.
40 Q&A. Teams complete a thorough patent search in the area of their project. Draft of report.

Table 3c N1D041 Syllabus—Part 3: Marketing Your Idea or Invention

Session 7 — "Selling" an Innovative Idea

41 Teams share the learning and insight gained from their patent searches. Q&A on Part 2.
42 "Producer" tasks: selling innovative ideas and/or preparing implementation plans.
43 The process and advantages of licensing to a large company.
44 Teams use creative problem solving to develop marketing or implementation plans.
45 How to prepare an effective 30-second message.
46 Each student prepares an oral 30-second message on how to sell the team's invention.
47 Students present 30-second messages and receive positive feedback on "what worked."

Session 8 — So You Want to Be a Millionaire

48 Launching a small business.
49 Business strategy. Self-evaluation form on being an entrepreneur.
50 Twenty ways to avoid failure (based on the creative problem solving process).
51 Resource acquisition: How to find venture capital and other funding.
52 Sources of information on the web on how to start a business.
53 Drafting of individual learning reports and teaming analysis.
54 Teams complete their written team project reports.

Session 9 — Team Project Presentations

55 Teams design a 20-minute final oral team presentation using creative problem solving.
56 Teams prepare the presentation materials.
57 Teams practice their presentations, including high-tech tools and props.
58 Presentation of project to an audience of interested guests and evaluators.
59 Debriefing: What was learned from the presentations?
60 Final course and learning evaluations. Close, with a celebration for a job well done!

Materials: The students were required to read Parts 1 and 2, plus Chapter 18, of the *Creative Problem Solving and Engineering Design* textbook[1] as well as the smaller *Break-Out Creativity* book[3]. Many of them found the material easy to read, learn, and apply, and they studied additional topics on their own. The students were given a Manual with capture sheets, forms, assignments, and hardcopy (three per page) of all overheads used to facilitate note taking. They were required to complete the confidential Herrmann Brain Dominance Instrument (HBDI)[1,4] and were formed into three teams of four based on the results. For each team, the objective was to have all thinking preferences represented with maximum diversity in thinking and educational background, but with the average HBDI profile of each team approximately equal. Each team had at least one member from business, engineering, and biological science.

Assessment: Quizzes on reading assignments, the 30-second message, and class participation together counted 20%. The individual learning report (including homework assignments) also counted 20%. The oral team presentation (with all members participating equally) counted 20%, and the written team project report (approximately 20 pages excluding appendix) counted 40% of the course grade. The grades in this class ranged from a low of 83 to a high of 96, and the students exhibited a remarkable degree of development and learning. Primarily, their reports were downgraded for spelling and grammatical errors that could have been eliminated by an additional round of proof-reading. However, the students were working under severe time pressures to complete the course work before the start of the next class in the program.

Experiences: The students learned new thinking and teaming skills—some of their comments are listed in Table 4. They overcame the obstacles of difficult time constraints, communicating with team members of different fields and "opposite" thinking preference and different language/culture backgrounds, as well as team members joining a team late, working part-time, or being unavailable for several days due to illness. As can be expected, the pilot course took much time for material development, even though different parts were previously taught in other courses. Sessions 1, 4 and 7 were scheduled for a 4-10 p.m. time slot due to a severe classroom shortage on campus. This led the instructor to condense some of the topics (or to assign them as homework) to keep the evening sessions to less than four hours.

Project Outcome: The students' efforts, initiative, and team presentations were impressive:

- Team #1 tackled the problem of temporary workers who have to waste much time and effort in completing and handing in time sheets to get paid. The team invented and developed a software "business solution" named **eTime**[Group1] which is estimated to save the average agency around $20,000 per year.
- Team #2 focused on the fashion world and wanted to solve the problem of economically matching bra straps with women's outfits. Their customer and marketing research and competitive analysis were outstanding, as was their powerpoint presentation. To get around previous patents, they invented the multi-back™ for their "strappi bra."
- Team #3 had a rough start since patent searches showed that several of their ideas had already been invented. Finally, they chose to work on one topic, with the intent of improving the concept and finding new applications. They developed a vibrating device to alert people who are out of earshot of a ringing telephone. The market potential among elderly people was (as expected) very good, but a secondary market among office workers was identified for "the gift of silence" made possible by their retrofitable vibrophone™.

Table 4 Student Feedback, Course N1D041

"During my entire education I have not partaken in a course in which I have achieved so much in such a short time and enjoyed every minute of it."
"The course gave me insights into my own abilities and how they compare to others. I have gained a new outlook on interactions between people through my experience with heterogeneous teams."
"I enjoyed participating in this course and would be as bold as to say it has probably been my most favorite module I have taken at University ... by allowing the best solutions to be created by the teams."
"By understanding exactly what creativity is, how it is achieved or lost, and its applications in the business world, I am now able to enhance my own creative thinking. Not many courses teach self improvement on a metacognitive level that can be applied to both everyday and workplace situations. This course has taught me what it takes to be an entrepreneur and made me realize that it is not beyond my capabilities."
"I am used to having engineering lectures with over one hundred people, which are very boring and monotonous. This module was very hands-on and interactive, keeping our interest well beyond the classroom."
"Whether I become an entrepreneur or work for a company, the skills I have learned are multi-transferable; they can in fact be used in nearly all aspects of life."
"I would like to apply my knowledge of working in whole-brained teams to gain maximum efficiency. I have learned to defer criticism and judgment until the correct time, as well as how to communicate better with people of different thinking preferences. Ultimately, I would like to use what I have learned to become a successful businessman and entrepreneur."
"Taken as a whole this course has brought about a change in thinking as any course does, but in this case the change is in fundamental thinking patterns to do with communication, approach to solving problems, teaming abilities and innovative business insight. For me the course was exciting because of its relevance to almost anything I choose to do in the future."
"Understanding myself, the way I think, has made it easier to concentrate on my weaknesses. I have realized that my imaginative thinking has a use and I no longer have to suppress it. My general approach to life has also taken a dramatic turn for the better. I can now see the benefits of planning and organization. After completing this module I now have a focus on the type of career I would like to pursue. I feel that with my strengths I would enjoy a job in biotechnology that involves team responsibilities and a job that is dynamic and unpredictable."
"I believe that by taking part in this new course I have learned a large amount of knowledge ranging from thinking about inventing things to running a truly successful business. Most importantly, by understanding my thinking preferences and working towards developing my weaker disciplines I will gain an advantage over other people who do not understand these concepts. In the immediate future I think this course will prove extremely beneficial as we can use the HBDI results to form optimum teams for class and industry projects."

The development of this course (and the MSc program) is being funded by a government grant through the University of Nottingham Institute for Enterprise and Innovation. The Institute was established as a result of a stiff competition among UK universities to develop programs that would help create new businesses and new jobs[5,14].

IV. MODULE 12 "Creative Problem Solving and Entrepreneurship"

This concentrated course was the last in a part-time MBA program offered in Singapore by the School of Business of the University of Nottingham. It had a dual focus on entrepreneurship (theory based) and creative problem solving (hands-on team project) and was taught on two full days on a weekend, followed by four evening sessions. Because the students had full-time jobs, most of the project work had to be done in class. They were given two months to study for a final examination covering the entire program and to complete a 4000-word learning summary for this course. Each topic listed in Table 5 was formatted to be covered in 30-40 minutes.

Table 5 MODULE 12 Syllabus

Part 1 — Entrepreneurship in the 21st century. Creative thinking and creative problem solving.

1 Course introduction and objectives.
2 The surprising neglect of entrepreneurship as an area of study.
3 Some definitions of entrepreneurship.
4 Quiz. The Herrmann model of brain dominance. Confidential HBDI results.
5 Implications of the HBDI for communications and teamwork. Whole-brain teams.
6 Overcoming barriers and mental blocks to creative thinking.
7 Overview of the creative problem solving model. Problem definition.
8 Idea generation and creative idea evaluation. Inventive thinking exercises.
9 Critical idea judgment. The Pugh method for developing optimized solutions.
10 Solution implementation. Review of Day 1 learning.
11 Joel Barker video on paradigms. Assignment: Identification of a simple project topic.

Part 2 — Entrepreneurship, invention, and innovation. Team project application.

1 Theories of entrepreneurship.
2 Towards a synthesis—catalytic, allocating, and refining entrepreneurship.
3 Creativity, invention and innovation—what makes an innovative organization?
4 Teams select a problem. Customer survey/research. Problem definition statement.
5 Creative thinking warm-up exercise. Teams brainstorm ideas for their problem.
6 Teams improve their creative ideas and develop concepts for the Pugh evaluation.
7 Pugh method Round 1 evaluation.
8 Round 2 evaluation of concepts using criteria that consider economics and marketing.
9 Theories of entrepreneurship revisited—input completion across all factor markets.
10 Based on Round 2 results, teams choose their "best" concept for further development.
11 Project documentation; review of learning; looking ahead to Part 3.

Part 3 — Entrepreneurship in action. Project presentations.

1a Protecting an invention; intellectual property/patents.
1b Useful web sites. Screening ideas. Evaluating market and innovation opportunities.
1c Licensing and selling an invention to a big corporation. The 30-second message.
1d Teams further develop their projects and draft up report notes.
2a Finance gaps in theory and practice.
2b Strategies for launching a small business. Franchising. Prototyping. Self-assessment.
2c Teams design an oral presentation (15 minutes) along with required visual aids.
2d Teams finalize their presentation and review their readiness for giving their presentation.
3a Teams submit copies of their presentation materials and outline.
3b Creative problem solving review: Twenty ways to avoid a business failure.
3c,4a Team presentations, with order determined by lot (15 minutes plus 5 minutes for Q&A).
4b,4c Feedback on effectiveness of presentations. Course evaluation; final Q&A session.
4d Review of assessment requirements: individual reports and course examination. Celebrate!

This class had 39 students. Thirty-five were formed into seven heterogeneous teams with five students each based on their previously submitted HBDI data. The remaining four made up the eighth team. The teams worked very hard on their projects, some staying in the lecture facility until 2 a.m. Overall, course evaluations for the creative problem solving portion were the highest of all the modules in the program. The predominant thinking style of the students was very analytical, whereas typically, entrepreneurs exhibit strong right-brain thinking modes. These students had to be taught lateral[13] and creative thinking techniques; they found "looking for more than one right answer" very difficult to do[1]. One left-brain thinker who used to be bureaucratic in outlook and rather critical of co-workers (finding the "oddballs very irksome") had this to say two months after the end of the course: *"I aim to be a creative manager and would like to educate my team members on creative problem solving for common understanding and shared values on creativity and innovation. I would like to encourage team members to be individuals who will learn to communicate the excitement of discovery and not ridicule the ideas of others for being different. I want to continuously explore with business associates new innovative solutions. When successful we can call ourselves practicing entrepreneurs. My goals in entrepreneurship would be to break through into new horizons in as many areas as possible."*

V. Conclusion and Recommendations

The author has years of experience teaching creative problem solving in many different formats, from two- or three-day workshops in industry to one, two, or three-credit hour courses in engineering programs, by extension, or as an enrichment program for students from 6th grade on up[8-10]. In the last two years or so, the topic has been expanded to include invention, innovation, and entrepreneuring. Few engineering programs today have a comprehensive entrepreneurship options (or series of classes) that teach the entire process from inventive idea to launching a successful business. Many business courses teach how to run a business or how to help emerging or established companies be more successful—they do not teach how to invent a process or product and then start up a company.

Based on the experiences in these three courses, as well as other creative problem solving, design, and invention classes, the following factors and conclusions are deemed important for effective learning, an effective academic program, or successful company:

- Support by administration or managers and peers—there must be a climate that makes innovation and creative thinking not only acceptable but recognized and rewarded.
- The age or maturity of the students is irrelevant, as long as the material is adapted to their age level, and as long as it is presented interactively to their learning styles. The author has taught very successful classes to junior high school as well as master level students.
- The model has to be immediately applied to an interesting, relevant project. If the project can be carried forward to the prototyping stage, so much the better. Thus having even a modest amount of funding available for this purpose is of tremendous benefit.
- Sufficient time must be allocated—a one-credit hour module makes it difficult to provide the required depth, and it does not emphasize that this learning is important. When students get exited about their invention, they will spend an extraordinary amount of time developing their idea (which can negatively impact their other studies, unless they are given an adequate amount of time and other necessary support). Thus a four-week concentrated (single) course is more productive than a one-week condensed version. A

three credit-hour semester course (as a minimum) can have substantial results and initiate an invention, whereas a one credit-hour course cannot do much more than provide the foundational framework for subsequent application in a design project, thus losing the benefit of just-in-time learning.

- The foundational skills (lateral thinking, teaming, communication) as well as the four-quadrant thinking and creative problem solving models are key and must not be neglected or skipped, if promising inventions or entrepreneuring ideas are sought.
- Ideally in an engineering program, these foundational skills should have been learned by the junior year as part of an integrated approach that moves from introduction to engineering to the senior design project[9-12]. Students (and faculty) should be accountable for applying this knowledge in any course that requires a team project. The results will not only consist of higher efficiencies in time, but will achieve a significant increase in the quality of teamwork, project outcomes, and learning.
- Creative problem solving and invention/entrepreneuring are closely linked. If either one is taught without the other, the results most likely will be unremarkable. Creative problem solving teaches the foundational thinking skills, and invention and entrepreneuring require their applications at several levels and iterations, thus immediately demonstrating the usefulness of the model and thinking skills.
- Courses of this type are needed to retain creative students in engineering—these right-brain thinkers are sought by innovative companies, either as intrapreneurs or as suppliers of innovation through their own enterprises[11].

At present, we as engineering educators have only scratched the surface of what could be envisioned and done if courses of this type became the core, instead of a band-aid patch, in engineering and multi-disciplinary education.

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Bibliography

1. Lumsdaine, E., Lumsdaine, M., & Shelnutt, J.W. *Creative Problem Solving and Engineering Design.* McGraw-Hill Primis (1999), ISBN 0-07-236058-5.
2. Pugh, Stuart. *Total Design: Integrated Methods for Successful Product Engineering.* New York: Addison-Wesley (1991).
3. Crandall, R. (editor), *Break-Out Creativity.* Corte Madera: Select Press (1998).
4. Herrmann, Ned. *The Whole Brain Business Book.* New York: McGraw-Hill (1996), ISBN 0-07-028462-8.
5. Binks, M., Gibbs, B., and Lumsdaine, E. Interdisciplinary Courses to Enhance Creativity, Innovation, and Entrepreneurship. Sixth European Conference on Creativity & Innovation, Lattrop, Netherlands (12/1999).
6. Fussell, David A. The Secret to Making Your Invention a Reality: The Workbook. Ventur-Training L.P., Duluth, GA 30136 (includes a tape series), ISBN 0-9639336-1-2.
7. Pliniussen, J. ADMN 3717EQ Innovation and Creativity. *Course Manual.* Nipissing University, Centre for Continuing Business Education (Spring/Summer 2000).
8. Lumsdaine, E. and Lumsdaine, M. Math/Science Saturday Academy. *1992 ASEE Annual Conference Proceedings,* Toledo, Ohio, Vol. 1, pp. 640-646.
9. Lumsdaine, E. and Lumsdaine, M. Teaching Creative Thinking Skills and Problem Solving to Engineering Freshmen. *1990 ASEE Annual Conference Proceedings,* pp. 1716-1720.
10. Lumsdaine, E., Shelnutt, J.W. and Lumsdaine, M. Integrating Creative Problem Solving and Engineering Design, Session 2225, *1999 ASEE Annual Conference Proceedings,* Charlotte, North Carolina (CD-ROM).
11. Lumsdaine, M. and Lumsdaine, E. Thinking Preferences of Engineering Students: Implications for Curriculum Restructuring. *Journal of Engineering Education,* 84:2 (1995), pp. 193-204.

Web Sites Found Most Helpful by Instructor and Students (there are many others):

12. www.engineering-creativity.com Teaching Manual for Reference 1.
13. www.edwdebono.com Edward de Bono is a strong proponent of lateral thinking. Look for the 3-spot game.
14. www.nottingham.ac.uk/enterprise The site contains information on the UNIEI and the "concept bank".
15. www.innovation-institute.com This is a reasonably-priced commercial site for evaluating creative ideas.
16. www.patent.gov.uk The British Patent Office has lots of helpful information (provided also by phone).
17. www.inventnet.com This is a very useful site for students to explore.
18. www.uspto.gov This is the official site of the US Patent and Trademark Office, crucial for patent searching.
19. www.patents.ibm.com This site is recommended for students to do initial patent surveys.
20. www.sba.gov This is a great source of information for starting a business, including writing a business plan.
21. www.nesta.org.uk Students in the UK can submit their ideas for evaluation (and possible venture funding).
22. www.nciia.org This is the primary funding source for US student invention projects.

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