Abstract: This report is on five years of our experience in involving primarily biomedical engineering students in the design, development of products with commercial potential. Twenty such projects have been completed, involving about 100 students working in self-selected teams. Each team develops technical, marketing and business plans, develops and tests its prototypes and submits a proposal to NCIIA for a grant. As of 2005, four such grants have been awarded and one U.S. Patent application has been filed.

Our Technical Entrepreneurship program is five years old. It has been supported by two grants from NCIIA. Grants from the National Collegiate Innovators and Inventors Alliance supports program development in entrepreneurship and individual “E-team” projects proposed by student teams. “E” stands for Entrepreneurship or Excellence.

Although we planned to involve engineering students from the entire College of Engineering and from the Business School, the overwhelming majority of the approximately 100 participants to date have come from Biomedical Engineering. Participation by others has been hindered by some interdepartmental problems of controls and bureaucratic rules. Perhaps these difficulties are generic and arise from the engineering tradition of professional isolation by specialization. Entrepreneurial product development needs teamwork involving technical specialists as well as those skilled in business. The goal was to introduce the participants in many facets of entrepreneurship ranging from a search for projects with commercial potential, project selection, product specification, technical plan, market research, business planning and prototype development followed by testing. Twenty projects have been worked on. Each student participates for at least two semesters, but some projects continued beyond that point. The majority of the participants are seniors; the team project is equivalent to the otherwise mandatory senior design project or capstone project required for accreditation. Juniors and graduate students have also participated with mostly senior teammates.

Common problems encountered and potential solutions:

1. Fear of open-ended problems leading to initial paralysis.

   Generate outlines of multiple solutions and discuss their merits.

2. Team leaders are relatively powerless over their partners.

   Discussion of the importance of a central coordinator with shared responsibilities for success and failure with the team members. No scapegoats!

3. Team members bury themselves in narrow areas instead of collaboration.

   Encourage team meetings and engage everyone in the resolution of problems.

4. Communication within teams.

   Use of email and WIKI server with access to all team members.

5. Fear of confidentiality problems.

   Keeping good notebooks and submitting disclosures of inventions to the Office of Technology Transfer at the University.

6. Fear of spending funds on samples.

   Explaining to the team members the difference between the cost of an engineer’s time vs. the cost of materials and the importance of timeliness.

7. Delegation of work and outsourcing.

Inviting entrepreneurs to talk about their own team approach.

8. Seeking formulas for project management and development.

   As instructors, we have little faith in formulaic management, therefore we encourage the team to seek unorthodox approaches appropriate for their specific goals.

9. Difficulties in product, performance specifications.

   Develop three lists: must have, nice to have, gee-whiz, wouldn't it be great!

10. Problems in graphic and verbal communications.

    Critiquing the students' drawings in their notebooks and showing 3-D and planar illustrations while discussing potential design solutions.

All these solutions are partially effective and ad hoc solutions are generated as problems arise. We have not found any magic formulas to overcome these problems in an automatic manner. Each project and each team tends to generate its unique conflicts and problems. The experience is generally equivalent to "life in the trenches."

Despite these problems, the participants have expressed that the experience of creating a new enterprise was valuable, especially for those who went to work in industry.

Problems encountered by the instructors:

1. Communicating the importance of idea generation, especially in creating a freewheeling environment.
2. Stopping inappropriate projects without becoming dictatorial.
3. Encouraging independence.
4. Encouraging networking outside the university's boundaries, such as connecting with local firms.
5. Finding space and funding for a multidisciplinary development studio.
6. Convincing faculty members to steer their students into interdisciplinary design.
7. Introducing participants to the real business/industrial world by inviting successful entrepreneurs to address the students focusing on specific topics such as team building, business plans, market studies, intellectual property, prototype building, financial plans, promotion, etc.
8. Establish continuity for the survival of teams and their promising but incomplete projects.

Project selection criteria: We developed a rating form for the proposed topics and asked the class to assign points on a scale of 1 to 5 for each factor. The following factors were considered:

►Technical Challenge?	►Novelty?	►Realistic time schedule (9 mo.)?
►Market Potential?	►Suitability for teamwork?	►Are the skills available?
►Market Size?	►Cost of a prototype?	►Personal factors – is it fun?
►Quality of the description?	►Are the resources available?	►Potential appeal for licensing?

Team size: 2 to 8.

Some completed projects:

Magnetic Field Detector and Mapper (1999-2000) – 5 members

Arthroscopic Knee Simulator to Train Surgeons (1999-2001) – 8 members

Portable Insulin Cooler (2000-2002) – 8 members

Weather Protection for Wheelchair Users (2000-2001) – 5 members

Surgical Introducer for a Breast Implant via Transaxillary Approach (2000-2002) – 4 members

Zip Band: A "Revolutionary" Tool for Delivering Dental Fillings (2002) – 2 members

Fool-Proof Eyedropper (2002-2004) – 2 members

Sore-No-More Spinal Board (2003-2004) – 7 members

"R-TONE" (Assistive device for mild hearing impairment) (2003-2004) – 8 members

Neonatal Respirator (2003-2004) – 3 members

Fireman's helmet with enhanced communication and protection – 5 members

Oxygen saturation monitoring within a firefighter's helmet with two-way communication and one-way data transmission of physiologic data – 5 members

Summary and Conclusions

Success stories: 4 Advanced E-Team Awards from NCIIA
1 US Patent pending
1 SBIR proposal received encouragement to resubmit
1 special award from the Center for Aging at the University
Students from electrical and mechanical engineering are beginning to join the BME teams.
An interdisciplinary doctoral student in Entrepreneurship (S. Wills), who holds an MBA has joined the instructors as a volunteer.
Participation in local and televised enterprise forums.
Gathering external support for the creation of a studio.

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