Can Students Help Entrepreneurs? An Evaluation of Linking Academic Technology Entrepreneurship Courses With Dislocated and New Entrant Workers to Foster Start-ups

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Abstract

This paper discusses and evaluates Lehigh University's demonstration program integrating technology entrepreneurship courses with state and federal career and employment agencies. The demonstration involved three stages over a 30-month period in the context of Lehigh's Integrated Product Development Program. IPD engages students, faculty and courses from business, engineering and design arts. Multidisciplinary student teams work on a wide range of industry-sponsored projects, and clients in this demonstration were dislocated workers with entrepreneurial new product ideas. This paper details the demonstration program's goals, activities, resources and structure. We then analyze the results of the comprehensive assessment process and discuss lessons learned.

Keywords: Entrepreneurship, New Product Development, Inquiry-Based Learning, Project-based Learning, Multidisciplinary Teams, Collaborative Learning.

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Introduction

This paper discusses and evaluates Lehigh University's implementation of a two-year demonstration program, funded by the US Department of Labor, integrating technology entrepreneurship courses with state and federal career and employment agencies. The objective was to evaluate the feasibility and impact of an integrated partnership of academic, government and private entities for economic development based on new companies started by entrepreneurial dislocated workers and new-entrant workers. The demonstration was carried out in the context of Lehigh's Integrated Product Development (IPD) Program. Student teams from business, engineering and design arts work on a wide range of industry-sponsored new product and process design projects.

The program consisted of three stages over a 30-month period. The first involved recruiting and selecting from among more than 200 applicants those most likely to benefit. Second, each of the 11 selected participants worked with multi-disciplinary IPD student teams in a year-long sequence of related technology entrepreneurship, product development and marketing courses. In the final stage, interested participants received assistance from the Technology Business Development Program at Lehigh's Small Business Development Center and some pursued their ideas further with Pennsylvania's Ben Franklin Technology Partners center based at Lehigh or on their own.

This paper describes the program's goals and activities in detail, including the context in which it was conducted, its organizational structure, associate agencies, facilities and expenses. We also overview the interdisciplinary new product development courses involved. We then describe the comprehensive assessment process used, summarize the resulting feedback from the selected participants, students and faculty, and evaluate the degree to which these activities contributed to the objectives, where they might have been strengthened and lessons learned. Our aim is to guide other academic institutions seeking to start similar programs.

Program Description and Resources

Lehigh University Context. The 1,600 acre campus of Lehigh University is located in Bethlehem, PA, 75 miles west of New York City and 50 miles north of Philadelphia. The university is private, co-educational, non-denomination and serves ~4,600 undergraduates and ~2000 graduate students, of whom ~58% are male and 42% female. Students enroll in four colleges: arts and sciences (45% of undergraduates), business (25%), engineering (30%) and a primarily graduate college of education. Lehigh is considered in the class of "highly selective" schools with combined SAT scores ranging from 1230 to 1370, and is consistently among the top 40 US national universities in *US News*'s annual rankings. The student body represents all 50 states and 65 countries, with the majority from Pennsylvania, Delaware, New Jersey and New York. There are approximately 440 full-time faculty members, 99% with Ph.D. or other terminal degrees. Lehigh University is a class R2 research school with annual research funding of ~$45M and 24 research centers or research institutes.

Integrated Product Development (IPD) Program. The demonstration ran in the context of Lehigh's national-award-winning Integrated Product Development (IPD) Program [1]. IPD fully integrates the three fundamental pillars of successful product design and commercialization: design arts, engineering and business. The Program engages students, faculty and courses from the College of Arts and Sciences, the College of Business and Economics, and the P.C. Rossin College of Engineering and Applied Science. Student teams comprised of all three disciplines work on a wide range of industry-sponsored projects--from the development of entirely new products (and even new companies), to the redesign of existing products, to the improvement of manufacturing processes.

IPD began in 1994 in response to a need for college graduates prepared to work in group settings as multi-functional, self-directed and team-oriented professionals. So, IPD provides opportunities for students to address real-world problems, design solutions and develop business plans to commercialize those products or processes. IPD supports a mix of flexible, interdisciplinary academic courses within engineering, business and design arts. In the year-long capstone projects course, students work in multidisciplinary teams for corporate partners throughout the design, engineering and marketing stages of

product development. Students experience firsthand entrepreneurial product design and commercialization. Annually, approximately 150-200 students from 20-30 majors work in 30-35 teams with 15-20 faculty advisors and 20-25 sponsoring companies.

The demonstration activities were supported by IPD program support staff, which include: a faculty member as program Director; an Outreach Manager responsible for interactions with industry clients; a Program Manager responsible for budgets and facilities; an Academic Administrator responsible for the capstone course; a part-time Project Evaluator, three graduate student consultants (one each in engineering, business and design arts); and an Administrative Coordinator for secretarial support and office management.

The demonstration began on July 2, 2001. The publicity and selection stage ended in January 2002. In the second stage, January-December 2002, the participants worked with student teams in the spring and fall semester IPD capstone courses. Third,, the IPD staff arranged for interested participants to pursue their business plans further with two associate agencies, discussed in more detail below. Several also continued business development on their own.

Associate Agencies. One of the goals was to show whether academic, government and private agencies can work together to spur economic development. This was done by assisting dislocated or new entrant workers in their attempt to become self-supporting through start-up companies. The project coordinated efforts with three outside agencies to recruit eligible applicants, provide services to those not selected, and help the selected participants pursue their business plans after the coursework. The three agencies were the Lehigh Valley Workforce Investment Board (LVWIB), the Small Business Development Center (SBDC) and the Ben Franklin Technology Partners (BFTP).

The Lehigh Valley Workforce Investment Board is located in Allentown, PA. Its mission is to unify workforce services for employers and job seekers, align workforce development with economic development resources, and maximize access to the workforce delivery system. A committee chartered by the LVWIB connects employers with qualified job seekers. Services include skills and abilities assessment, job search and placement assistance, and financial aid for training and education programs.

A second associated agency was the Small Business Development Center, located in the College of Business and Economics at Lehigh [2]. It provides services, such as financial, marketing, production, technology development, organizational and human resource assistance, to more than 1000 small businesses and potential entrepreneurs annually. A free counseling service may include several interviews and on-site visits. Funding comes, in part, from grants from the Commonwealth of Pennsylvania's Department of Community & Economic Development, and from the U.S. Small Business Administration.

Third, the Ben Franklin Technology Partners of Northeastern Pennsylvania (BFTP) provides funding and services to clients with strong potential to create or retain jobs and have positive impact on the region's economy [3]. The agency invests approximately $5 million annually in funding and services, with typical individual investments between $30,000 and $150,000 per year. In cases needing significant funding, and with sufficient potential benefits to the region, staff help clients prepare a formal request for funding. Selection is very competitive. BFTP also uses an extensive network of outside resources to support emerging businesses, such as connecting them with Lehigh and other universities' faculty and/or professionals in strategy, marketing, financing, business planning, human resources, and technical issues. More specific to IPD, over the years BFTP has provided funding to enable several businesses to participate in IPD capstone courses.

Expenses. Over the demonstration period, July 2001 through December 2003, US Department of Labor grant funds of $556,000 covered: 1) faculty and staff support, 2) graduate student support, 3) computers, laptops, projection systems and office supplies, 4) recruitment publicity, 5) questionnaires, and 6) student team prototyping and other project expenses. The faculty project director (one of this paper's co-authors) received one month summer support the first year. The Outreach Manager received 18 months full-time support. He was then was promoted to Professor of Practice at the University, at which point he continued to support the capstone projects, with salary from an internal budget. All other faculty were from regular teaching loads in academic departments, funded internally. The grant also funded assessment costs, with an internal evaluator (another co-author) receiving 30 months support for 45-50% time. Additionally, a paid external evaluator did four semi-annual evaluation reports. Two

graduate student consultants received stipend and tuition for 30 months. A third was funded internally. The project also acquired computers to be used by the Academic Coordinator and the graduate consultants, as well as several laptops and projection systems for student teams' presentations to their client entrepreneurs and others. Grant-funded ads in regional newspapers recruited potential clients. For part of the participant selection process, we purchased 40 copies of the Entrepreneurial Quotient questionnaire from Wonderlic Inc. Finally, the student teams spent funds for prototyping and materials, printing and mounting of posters, travel and printing reports.

Evaluating Program Activities

The evaluation in this paper consists of two parts. The first follows the outline of the Service Model included in the grant proposal to DoL (Figure 1). We discuss each activity and assess its contribution to the short-term project goals. Second, we describe the progress of the client entrepreneurs compared to a small control group of unselected applicants. We include perceptions of the participant groups, our reflections on the process and outcomes and lessons learned. Given the early stage of these entrepreneurial companies, assessing longer-term economic impact is beyond our scope, as the clients continue to pursue funding and follow through on business plans.

Planning. Early in planning this demonstration, we reviewed the literature and interviewed individuals involved with entrepreneurship to identify characteristics associated with success. We developed and sent a survey to 22 entrepreneurs, 64 professors (the majority with personal experience as entrepreneurs) and 19 professionals who deal with entrepreneurs. Fifty (48%) responded by rating 32 characteristics on five-point scales from "no influence" to "extremely influential." We factor analyzed, grouped and ranked the items according to perceived influence (Table 1). This informed the development of three instruments used in the application process discussed below.

Early in the demonstration, the staff met bi-weekly to review policies and strategies. After the capstone courses, meetings continued monthly. The IPD Program Director, Outreach Manager, Program Manager, Academic Administrator, internal Project Evaluator and Administrative Coordinator attended.

Other participating faculty attended periodically. In addition, at the conclusion of each course, staff met to review student, faculty and client feedback as well as student deliverables to the clients and course evaluations.

Analysis. The regular meetings were extremely useful for keeping everyone appraised of the status of the various activities. The bi-weekly frequency suited the level of staff involvement in each stage and promoted a team-like atmosphere. The staff discussed and attempted to address any problems in a timely fashion. Similar scale programs would do well to schedule periodic meetings of all support personnel.

Recruitment. In 2000-2001, several large employers in our region underwent painful restructuring, (e.g. Lucent Technologies, its opto-electronics spin-off Agere, and now-shuttered Bethlehem Steel). However, our initial plans targeting dislocated workers from recently downsized firms proved of limited value, resulting in only 15 inquiries. The Lehigh Valley Workforce Investment Board assisted by providing a list of downsizing companies, and inviting the Outreach Manager to join their presentations to dislocated workers at these downsizing firms, and to participate in a LVWIB-supported job fair. To reach a wider audience, two of this paper's co-authors publicized the opportunity on *Job Quest*, a Lehigh Valley television program. Our appearance led to five inquiries.

Analysis. By far the most successful (and time-efficient) publicity was ads in four area newspapers: *The Morning Call* (Allentown), the *Reading Eagle*, the *Philadelphia Enquirer* and the *Wilkes-Barre Times Leader*. This led to 181 inquiries, more than 50% through the *Morning Call*, the closest to Lehigh. Eleven additional inquiries came from Lehigh graduates or through connections to Lehigh, leading to a total pool of 212 individuals.

Screening and Selection. From the survey on entrepreneurship described above, we developed three instruments for the application process. The Appendix shows an example page from seven-page, 47-question Tier I form. Tier II was 8 pages and 72 questions. Tier III was a semi-structured instrument with 10 questions for in-person interviews. These instruments formed three screening tiers, intended to narrow the number of applicants successively. As shown on Table 1, our survey of experts in entrepreneurship produced six major factors associated with successful entrepreneurs. In order of perceived influence, they

are: 1) Passion/ Commitment, 2) Knowledge of the Market, 3) Product Characteristics, 4) Characteristics of the Entrepreneur, 5) Skills of the Entrepreneur, and 6) Personal Conditions. Questions regarding the most influential factors were included on the first tier instrument and the remaining factors on the second tier. The third tier was to include an interview with a selection panel, which would rate qualities associated with each factor.

When the Outreach Manager joined the project, as a previously successful entrepreneur he felt the selection process should be more one-on-one. Interested individuals contacted him, and he explained the process. Through information they provided, he decided whether their business idea fit the IPD model, which included two sets of criteria. The first dealt with the product idea, that is: whether it was product-oriented as opposed to service-oriented; size-appropriate; required only resources readily available at Lehigh; contained business, engineering and design arts components; and could be completed by student teams in two semesters. The second set dealt with the individuals: whether they were self-supporting for the duration of the project; were willing to make the time commitment; and had sufficient expertise in the product area. When the project fit, the individual received the Tier I application. If not, the individual was referred to the Small Business Development Center where they could meet with counselors to explore the idea's feasibility and get guidance on next steps. From the pool of 212 inquiries, 106 received Tier I applications, of which 53 (50%) were returned.

Though there was no systematic follow-up of non-respondents, reasons cited for non-responses included (1) the absence of a non-disclosure statement, even though the Tier I form requested a product description; (2) the absence of a signed contract agreement. We also suspect self-selection due to the content of questions, including realization of the level of product knowledge needed and work involved.

After receiving the completed Tier I applications, the graduate student consultants interviewed each of the 53 applicants in person for approximately an hour. They judged four criteria: Did the project fit the IPD model? What were the applicant's expectations and could they be met in the context of the capstone courses? Would they work well with the student teams and have enough knowledge of the market to provide appropriate guidance? How committed were they to their product idea?

The Outreach Manager and graduate student consultants held regular informal meetings to review the applicants, and invited promising candidates to complete the Tier II questionnaire and Wonderlic's Entrepreneurial Quotient questionnaire, which measures entrepreneurial potential. The selection team recommended ten projects that they felt would benefit most from the capabilities of the students in the IPD Program. The IPD Program Director gave final approval. One additional applicant participated through funds provided by the BFTP. With encouragement from the selection team, an additional 11 not-selected Tier I applicants eventually contacted the SBDC for further guidance.

Analysis. While interviews are a valid and useful means to get information, they can be influenced by an individual's personal prejudices. One of the shortcomings of the revised, more informal, selection procedure was that judging criteria were not written down prior to the interviews, although the broad topics on the Tier III instrument were general guiding principles. In retrospect, one set of questions asked of all applicants would be better, as would using information on the paper applications to prepare for each specific interview. Semi-structured guidance could target areas beyond the common questions for exploration in greater detail with a particular applicant, and to supply ratings that could help discriminate among equally strong prospects. The process also clearly highlighted for us that finding enough good real-word clients for dozens of student teams is a full-time activity. Doing this on top of a normal faculty load would risk significant headache throughout the process. The single largest benefit to IPD, long-term, of this demonstration project was its funding allowing us to add the Outreach Manager.

Selected Project Participants. The 11 selected entrepreneurs were each assigned either one or two student teams. All 11 were males and unemployed at the time. On average fairly well educated, three attended some college, five graduated college, two attended graduate school, and one completed all requirements for a Ph.D. except dissertation. Seven had some business training. The majority characterized their most recent jobs as managerial, technical, or other professional positions. Two were in sales-related positions. Seven had previous entrepreneurial activities, such as in landscaping, consulting or newspaper delivery. Three had been self-employed, and five had parents who owned businesses. For

the duration of the demonstration, all 11 supported themselves through temporary jobs, savings or investments and support from others.

Product Ideas. The entrepreneurial ideas generally involved product improvements rather than radical innovations. The 11 projects tended toward higher (but not the highest) technologies, and were: improved microwave telecommunications filters; an epoxy-and-Kevlar hoof coating to replace horseshoes (the most radical innovation of the group); an improved outdoor volleyball net system; an improved wildlife management (i.e. live trapping) system; a redesigned hoof-cuff for the meat processing industry; an override safety device for boats; an improved Ob/Gyn speculum; a digital table display for casinos; an improved monitor to track cardiac function; a novel hydraulic impact drill; and an improved handle and installation process for refurbishing lockers.

Preparation. The Project Director or Academic Coordinator and the Evaluator met with each selected entrepreneur to discuss expectations and overall goals, and to apprise them of resources and opportunities available through IPD and the university.

Analysis. These early meetings were useful for acquainting the participants with the project administrators and with how the IPD program works and what it can offer. They also helped prevent grandiose expectations by the clients.

Entrepreneurial Capstone Courses. In the IPD capstone courses, multidisciplinary teams from business, engineering and design arts develop new products, redesign existing products, or improve manufacturing processes. The student teams, with supervising faculty advisors and regular input from their client entrepreneurs, devote the first (spring) semester to market research, customer needs analysis, concept generation and selection, system specification, financial modeling, project management and documentation. In the second (fall) semester, the students revisit design details, fabricate and build a prototype system, subsystem or components, design and perform test protocols, plan for production, and revise the business plan and financial models. In both semesters, the students must design a poster, do an oral presentation and prepare a final report. These and other course issues are discussed more below.

During this demonstration, 11 faculty members advised 22 teams in the spring. Each faculty advisor who had not previously participated in IPD paired in apprentice fashion with an experienced IPD advisor. All students attended common lectures once per week, were required to meet their advisors once per week, and to meet on their own as a team at least one additional time per week. All teams had common deliverables. In the fall, several teams merged since some students graduated and others enrolled for only one semester, resulting in 19 teams and ten faculty advisors. There are no common lectures during the fall course, but again all teams have common deliverables. Before both semesters, the Outreach Manager and graduate student consultants met with each faculty advisor to provide an overview of the course, answer questions, and offer assistance at any time during the semester. With handouts they provided examples of how team advising and meetings might be organized. This and the new-advisor apprenticing aimed for some consistency in team management.

Analysis. Our post-course surveys suggest that advisors generally found the introductory meetings moderately helpful, particulalry to those without prior IPD advising experience. Such meetings should definitely be held with all first-time advisors. Meetings with experienced advisors are unnecessary unless discussing some new course feature. Apprentice advising is a one-time duplication of resources, with two advisors for some teams, but is especially useful where academic backgrounds bring little business or design and prototyping experience, or little experience with multidisciplinary team projects. Over time, this has substantially reduced inter-advisor variation in expectation.

Project Fair. At the beginning of the first course, the selected entrepreneurs attended a Project Fair. Each set up a station where he could meet students to discuss the product idea and answer questions. The stations included materials to explain or demonstrate their ideas. We also provided refreshment to make the session as inviting and enjoyable as possible. All capstone students attended and moved from station to station. They then completed a form to indicate skills, interests and four projects that interested them. Based on the students' preferences, expertise and outside interests, the Outreach Manager and Academic Coordinator assigned them to the various projects. For the following fall semester, most of the students

continued on the same project as during the spring. A small number changed as teams shrank due to attrition.

Analysis. The chaotic energy during the Project Fair is high and stimulating, as nearly 200 people mingle and converse, making this day among our favorites in the yearlong sequence of activities. Moreover, assigning teams based on preferences informed by the Fair appears to work reasonably well. There were few complaints about team assignments, although in the course evaluations at the end of each semester, a small number of students voiced disappointment that their teams were not as multidisciplinary as others, or about issues with the client, faculty advisor or other team members. This level of dissatisfaction is likely in any course involving teamwork on diverse projects. We also think the complaints from students about the limited degree of multidisciplinary skills on their teams is a healthy sign that they have understood its value, compared with functional silos.

Support Staff. Through both semesters, in addition to the faculty advisors, the Outreach Manager and graduate student consultants played supporting advisory roles to the teams. They attended lectures, team meetings, and suggested and marshaled resources to promote teams' progress. Course evaluations reflected a great deal of variation in the extent to which teams valued this input. Some fully agreed that they served a valuable role in the team's progress, and others believed that they were not helpful. Approximately a quarter of the students agreed or strongly agreed that the Outreach Manager played a valuable role in the spring, as did 44% in the fall.

Additionally, the Academic Coordinator managed the project accounts, coordinated the poster session and presentation schedules, and saw that copies of posters and final reports were delivered to the client entrepreneurs. Once again, there were mixed feelings, with a third of the students agreeing or strongly agreeing her role was valuable to the team's management in the spring and 40% in the fall.

The Academic Coordinator also managed the course website, which included links to Announcements, Course Information, Staff Information, Course Documents, Assignments, Communications, Discussion Board, Groups, External Links, Tools, and a Resource Center. This website provided one way for teams to communicate with each other, with the faculty advisor, and with their

client. Unfortunately, in our follow up survey, only two clients reported using this. The faculty found the website moderately helpful, but it was more helpful to faculty who had not participated in IPD before. Approximately two-thirds of the students agreed the course website was useful.

Analysis. To better leverage these resources for students, we have since changed our process, giving the Outreach Manager and Academic Coordinator significantly more direct interaction with teams. A newly renovated 17,000 square-foot building, designed entirely to support student design teams, allows us to have all teams meet at the same time and place. The staff, and other resources such as reference librarians, can meet informally and regularly with all the teams, and students know they will be checking in periodically. That said, although a number of students did not value IPD staff contributions, these individuals were extremely valuable for the IPD Director, who was able to keep abreast of the teams' progress through the bi-weekly staff meetings. Also, the Academic Coordinator is vital in organizing course activities. Behind-the-scenes planning is not readily appreciated by students. The importance of these roles in supporting the teams should not be underestimated. Although not used as broadly as ideal for communication, a website containing all course information is a good mechanism for ensuring that consistent information is available to all participants. Some teams did use it extensively for document sharing, and we expect that use will increase as faculty become more accustomed to electronic course communications.

Troubleshooting Seminars. Based on feedback from the various participant groups during the spring, the IPD staff started a forum where teams could discuss their achievements and difficulties. The staff held four such seminars. These lunch-hour pizza meetings were intentionally rather informal. Each team was required to send one representative to each meeting, and the Outreach Manager and Academic Administrator facilitated. We hoped this would stimulate discussion and ideas that could benefit all the teams. Also, a requirement of reporting on their own team's progress and knowing how others were advancing would tend to keep the teams on schedule. In addition, the IPD staff used this time to review deliverables and deadlines.

Analysis. Although we did not get student feedback on the troubleshooting sessions, the Outreach Manager and Academic Coordinator believed the sessions were useful and accomplished their goals. So, with the new building this idea expanded into the common team meeting place and time discussed above.

Tack Board and Poster Presentations. For each semester, the teams produced a poster displaying their business and technical results and their design concepts. A brief workshop, by an adjunct professor in the Design Arts program, helped prepare the students. The outside of class workshop provided design tips to make posters attractive and informative. One member from each team was required to attend.

The spring poster session in April included 22 posters (36" x 48"). Team members stood by and responded to questions. For feedback, all students and faculty advisors completed evaluation forms on three posters assigned to them. Seven of the 11 client entrepreneurs also attended, as did representatives from the associate agencies.

In the spirit of continuous improvement, in the fall we added two tack-board sessions, during regularly scheduled class times in September and November, prior to the final poster session. These tack-board sessions created hard due-dates to stimulate progress, encouraged the teams to focus on content and getting mid-stream feedback on that content, without concern for more formal poster design issues. Faculty advisors and classmates provided constructive critique at each session to improve the quality of the final solutions. The final poster session occurred during the exam period in December. Once again, each poster was evaluated by other students and three faculty advisors.

The final posters were reduced to an 8½" X 11" format and provided to the client participants, who can use them in presentations to potential funding sources. The Outreach Manager also uses similar reduced versions of the posters in his recruitment efforts to demonstrate to potential project sponsors the type of work produced by student teams. Students too have used small versions of their posters during job recruiting interviews. The full-sized posters are on display in various campus buildings to help promote IPD to visitors and potential students. Sponsors do have the option on keeping a poster confidential.

Analysis. Along with the important promotional functions, posters creation is useful instruction for students in identifying and displaying their chief results. We have since continued and expanded the

outside of class poster workshops. Public display of the posters has also created expectations for succeeding classes. We believe the quality has been therefore successively better each year. While worthwhile, managing the posters displayed in public spaces is a minor logistical burden, and we recommend regular rotation and culling. Ad hoc feedback we get suggests that posters tend to lose their appeal after a year or two. To reduce the logistical issues given the volume of posters annually, we have also since installed two multiple-poster hanging rack display systems. We have also continued to use the tack board sessions, which proved a very valuable addition. These are community building moments for IPD. At the same time, they help teams gauge where they are relative to others, get early feedback from multiple viewpoints, and see the variety of problem solving approaches in other teams. Together with the initial Project Fair and Poster Sessions, which are also high-energy, these structured-chaos, community sessions have become our favorite activities in the capstone courses.

Oral Presentations. The student teams delivered oral presentations at the end of each term. They lasted from 35 to 50 minutes. Generally, each student presented one part of the presentation, and PowerPoint was used for illustration. The audience was other teams, other faculty and other clients. Students had to attend at least three other presentations and give peer feedback. The spring presentations included business and technical research, design concepts and preliminary recommendations. At the end of the fall, teams displayed prototypes and discussed testing and results. In our survey, the clients were between moderately and very satisfied with the student presentations.

Analysis. In addition to informing the client of the work done, the presentations require that the students work together as a team to develop the content and decide how to present it, reinforcing the teamwork aspects of technical businesses and improving communication and speaking skills. The client entrepreneurs asked questions and heard comments and questions of the other attendees. One improvement we have added since, to significant positive review, is setting up private discussion sessions between the team and client immediately after the oral presentations. This allows more time for in-depth conversation than the formal public presentation sessions, which has engaged the clients far more fully in feedback to the teams. We now wish we had thought of this straightforward approach many years earlier.

Written Report. If they followed the syllabus, the student teams developed final report content through a series of regular homework assignments. These roughly paralleled the suggested sections of the final report: Introduction, Market Opportunity, Customer Needs, Competitive Analysis, Target Specifications, Aesthetics and Ergonomics, Technical Concept Generation and Selection, Final Design Description, Prototype Fabrication and Testing, Production Plan, Financial Models, and Conclusions and Recommendations. Along the way, the teams did three preliminary drafts for advisor feedback. The final reports went to the client entrepreneurs. In our feedback survey, the participants were moderately satisfied with the final reports both semesters.

Analysis. The final reports are the most important deliverable for the class. They provide a full accounting of team accomplishments, document the entire development process, justify design decisions and provide the results of market research and financial analysis. Collective responsibility for a substantial, multidisciplinary document going to an external client is an important learning process for the students. When done well, many sections can be in the client's business plan for potential funding. Our experience suggests that the external client creates significantly greater intrinsic drive for the students to perform well than any faculty-created grade incentive ever could. Students also regularly use the reports during job interviews.

Capstone Course Review. This demonstration showed that student teams can be very useful to dislocated workers with product ideas. Clients responding to the Participant Survey indicated that they were between moderately and very satisfied with their overall experience. Unfortunately, one did not believe the student teams advanced his business. He thought his two teams unresponsive to his requests for testing and development and implied that it was due to student and faculty advisor arrogance.

Analysis. Some teams succeeded in realizing the participant's product vision. Others took a very different direction with new ideas that improved on the original. Unfortunately, two teams were unable to produce a working prototype. Yet, this too can be useful to experience that not all product development paths, even well executed, lead to success.

Post-Course Support for the Next Steps. The final stage in the service model, after the capstone, was to refer interested client entrepreneurs to the SBDC and Ben Franklin Technology Partners for continued development and financial assistance. So, after the fall semester, the graduate student consultant attempted to contact each client to assist them in the next steps. He spoke to eight of 11, and left messages with two others who did not return repeated phone calls. The remaining one had already received Ben Franklin Technology Partners funding to develop another product, and credits his association with the IPD Program through this demonstration.

Five interested clients were put in contact with a Project Manager at the Small Business Development Center, and three had meetings. They received advice on the next steps, information on a number of available resources and invitations to set up meetings with SBDC staff who would put them in contact with experts in areas such as import/export, financing, etc.

Another opportunity available to the entrepreneurs through the BFTP was to participate in a "tiger session." The entrepreneur presents his business plan to panelists who critique it and offer suggestions. This expert feedback can be extremely beneficial preparing entrepreneurs for potential funding sources. One client participated, presenting a business plan for a product other than the one developed with the student teams. However, it is not clear all participants were aware of this opportunity. When we contacted them to discover how participants became aware of this resource, some indicated this was the first they heard about it. After learning, one participant indicated interest and received contact information for the Regional Manager at Ben Franklin, who helped arrange a session.

In addition, five students wished to continue independent study work on their projects after the capstone. Three worked on the hydraulic drill and two on the hoof-cuff project. Unfortunately, the advisor and students on the drill project did not notify the client they were continuing. When contacted for feedback on the capstone, the client was not even aware of this work. He would have liked to discuss next steps with the students, but since by that point they had graduated, he merely requested their final report. The hoof-cuff team similarly continued through independent study. They and their advisor conferred with the client, and all appeared pleased with the interaction and progress. Based on the students' work, the

client entrepreneur received a provisional U.S. patent. However, the client later complained that some parts he had provided were missing. Some were broken during destructive testing, but others remain unaccounted for. We had no process in place for monitoring such details after the capstone.

Analysis. In retrospect, we believe we could have been more useful to clients had we had an explicit protocol for post-capstone collaboration. The decision to provide individualized support at the end of the capstone had advantages. The graduate student consultant was able to discuss specific needs and help set up meetings with associate agencies. This approach also had drawbacks. First, the consultant completed his work on the demonstration in March of 2003 and left the University. After his departure, no specific member of the project staff was assigned to follow up on the participants' progress, provide further guidance or answer questions. The Academic Coordinator responded to problems that arose, but the demonstration would have benefited by having an individual available to provide continued assistance. Another drawback is that participants did not receive consistent information on available resources. In order to leverage fully the valuable services available through the SBDC and BFTP, we should have documented for the clients resources available to them after collaboration with the students.

Feedback from Various Participant Groups.

Over the course of the demonstration, the clients, faculty advisors and students provided feedback on their experiences both informally and through surveys at the end of each semester. The spring after the capstone, clients discussed the the status of their business plans with the graduate student consultant. The the following fall they indicated tasks they had accomplished towards starting a business. In addition, the supporting staff provided feedback on their responsibilities and on the demonstration in general.

Client Entrepreneurs. Client satisfaction varied. The majority was moderately or very satisfied with the outcomes, but one was only somewhat satisfied and another not at all. Clients tended to be moderately satisfied with the amount of interaction with students and advisors in the spring, but were less satisfied in the fall. Several suggested that increased interaction might have avoided some misconceptions. They were moderately satisfied with the posters, presentations and final reports.

Generally, the entrepreneurs indicated they were moderately or very satisfied with their overall experience. Only one was just somewhat satisfied. Another refused to respond to the questionnaire because of the perceived team unresponsiveness noted above. Others, more satisfied with the overall experience, still mentioned that limited involvement with the students, especially in the second semester, negatively affected their experience. Since then, one method we have tried to address this issue is to institute, as mentioned above, the private discussion sessions following the oral briefings. We have also begun to require teams to email progress updates weekly to their clients, advisor and IPD Administrative Coordinator.

On the other hand, a number of clients said they learned a great deal. At times, the product development or business planning took unexpected directions, but they saw new ideas and completely new concepts. In February of 2002, one client wrote a letter to PA Senator Arlen Specter thanking him for the support for entrepreneurial dislocated workers through the US Department of Labor Demonstration Project at Lehigh. He explained to Senator Specter that the program has helped him enormously.

Faculty Advisors. The majority of the advisors were a great deal or completely satisfied with the capstone courses and working with the client entrepreneurs. The most positive aspect was working with students, whom they described as hard working, talented, pleasant and enthusiastic. In the first semester, the advisors were a great deal satisfied with client contact, but they were only somewhat satisfied in the second semester. In fact, a number of them were disappointed at the lack of interaction and the fact that many of the clients did not attend final presentations.

Students. Student teams varied widely in assessing how interested their clients were in the projects and how responsive they were to communication. Although some indicated positive interactions, by the end of the second semester, the majority felt their client was no longer interested in the project. This mirrors the feedback from the clients and faculty, so client communication was clearly a trouble spot.

Complaints notwithstanding, comparing our experience with more than 100 similar projects before the Dept. of Labor grant enabled us to hire the Outreach Manager, the communication was an order of magnitude better. In the spirit of continuous improvement, we hope we get better each year as we adjust

our processes. Yet the most significant jump in our 12 years in IPD was adding this Outreach Manager, whose primary job responsibility is recruitment of and liaison to clients. He interacts regularly with both the clients and the student teams, which enormously improves the two-way communication. Even so, there remains room for improvement.

By the same token, students viewed several things very positively. They liked, for example, the chance to participate in the entire product development process, to do hands-on work, and to build a prototype for a real-world project. As we mention above, we saw the fact that a number of student teams reported disappointment that their teams were not as multidisciplinary as others were as a positive sign of learning. We also have ad hoc feedback suggesting high utility for students in job interviews. They are able to talk with authority about experiences with multidisciplinary teaming, technical, business and design issues, and communication and management challenges. Recruiters are reportedly receptive. Lehigh's job and graduate school placement rate regularly remains above 95% within six months of graduation, and starting salaries are about 10% above national norms by field.

Project and Supporting Staff. Staff provided feedback on their responsibilities and how they changed over the course of the project. The Outreach Manager and graduate student consultant roles moved from recruiting and selection to monitoring and guiding the student teams. The staff enjoyed their work and felt positively about relationships with the others involved. Improvement suggestions involved defining project objectives earlier and more clearly, recruiting earlier, additional graduate student support, scheduling more meetings between the Academic Coordinator and faculty advisors to manage the class better, and establishing separate spending accounts for each team.

Interaction with Associate Agencies. One of the main demonstration objectives was determining whether an academic, governmental and private entities could integrate to assist dislocated workers in becoming entrepreneurs. In early meetings, the Executive Director of the LVWIB expressed doubt that the individuals who utilize their services would be appropriate candidates for the demonstration. Her expectations were accurate. Few individuals who heard about us through LVWIB contacts submitted

applications. Still, this type of agency should be made aware of similar resources potentially helpful to dislocated workers becoming self-supporting.

The Ben Franklin Technology Partners financially supported one dislocated worker's participation in the capstone courses and provided funding for another for a second invention. He credits the demonstration for this support, which he heard about through IPD. After establishing his business, he plans continued development on the product explored by the students. In the final stages of the demonstration, BFTP also made available a panel of experts to critique business plans and presentations. As we noted above, this resource was underutilized since some participants were unaware of it.

The Small Business Development Center usefully served in all three demonstration phases. In exploratory stages, the Executive Director provided literature used in SBDC entrepreneurial workshops, which helped us develop the application questionnaires. Then, 11 of the 43 non-selected applicants met with SBDC consultants for further guidance. In the final phases, an SBDC Program Manager met with interested participants for guidance on next steps.

Participant Progress

About a year after participation in the capstone, the client entrepreneurs received (by both mail and email) a questionnaire that included tasks associated with building a business. The tasks, as shown in Table 2, were ordered according to five stages of development: Early Planning, Higher Level Planning; Early Business Activity; Business Launch and Realizing Income. The brief questionnaire also probed future plans.

The internal evaluator attempted to telephone those who did not respond and sent several e-mail reminders. Seven of the 11 participants (64%) responded. The questionnaire also went to individuals who applied but were not selected. Nine of 41 (22%) returned it.

Results. Table 2 shows that the client entrepreneurs completed more tasks, and client entrepreneurs are more likely than applicants to have completed each task. Despite the small sample size, most of the differences in proportions are statistically significant (at $p<.10$). All of the client entrepreneurs who

responded created a new product design, and all but one created a marketing strategy, compared with only five of the nine non-participants. Five participants reported fabricating and testing a prototype, creating a marketing plan, forming a legal business entity, and establishing an office. Four non-participants created a prototype, but only two were able to test it. Three created a marketing plan, but none established a business entity or office. Five client entrepreneurs demonstrated their product to potential customers, and three established paying customers. Only one applicant completed these tasks. Two client entrepreneurs reported hiring employees, positive cash flow and profit, compared with none of the non-participants.

In addition, through e-mail, one of the non-responding participants indicated receiving a provisional patent. Another nonrespondents said by telephone that although not now pursuing further development of the IPD team's product, he is woking on other aspects of the business he created through the demonstration. The other two nonrespondents gave no feedback. There is no reason to believe they progressed beyond the initial development process.

Note that one client who reported profit does not attribute success to his participation. On the other hand, another respondent believes that his company would not exist without the demonstration. He received $100,000 from BFTP and is now seeking funding to begin production of a different product through contacts he developed by participating. The IPD product is in abeyance until the launch of the new product. To quote David Bonner with his permission:

> I cannot emphasize enough the significance and importance of this program to both Thor Power and the students. The IPD Program, supported by the DoL, for developing entrepreneurs, is the wave of the future. Without it, Thor Power probably would not exist. And, as a teacher as well, integrated thinking and teamwork are essential for the students.

Another respondent is now developing the product with a larger company, and another will continue development as cash is available. One participant is seeking funding so he can devote more time to the project and acquire supplies. Another is continuing to build the business, working on a different prototype, not the product developed by the student teams. Still, the participant describes working with the students as "a wonderful experience and very informative", and due to the students' research is exploring introducing the product into markets other than originally envisioned.

By contrast, only one unselected applicants plans to pursue the idea further, trying to find parts fabricator. Several applicants mentioned belief their product could have been successful had they been selected.

Conclusions

By these measures, participation by entrepreneurs in IPD through this demonstration was clearly, if moderately, helpful in enabling more rapid progress in the key steps towards starting a business. Given capstone course deliverables, each participant should have received market and technical research results in the final reports, a business plan, a marketing plan, and one or two working prototypes (depending on the number of teams assigned to the project in the fall semester). That there have not been more start-ups that are successful is likely due to several factors, not least of which is the sheer difficulty and overall high failure rate in starting any business. More specifically, the research may not have produced the results expected by some of the entrepreneurs, leading them to pursue other options. Second, where projects produced workable prototypes, some of these entrepreneurs may be unwilling to assume the risk associated with starting a business. Still, other client entrepreneurs are either continuing to develop the products further, seeking funding or starting to produce on a small scale.

When we correlated application scores from the Tier I and II questionnaires and the Entrepreneurial Quotient with a variable that reflects the highest stage of business development reported on the checklist, two of the scores were significantly related. One was family support, which was significant when all respondents were considered (r=.554, p=.02) and when the client entrepreneurs were analyzed separately (r=.916, p=.004). The other factor was knowledge of the market; however, this was only significant when the whole sample was analyzed (r=.565, p=.02). It was not significant when the unselected applicants and the client entrepreneurs were analyzed separately. The explanation for the joint significant correlation was most likely the fact that the client entrepreneurs were chosen specifically because of their knowledge of the market. Their scores on this factor were significantly higher than those not selected (89.3 vs. 72.8 respectively), and by being accepted into the demonstration they completed more tasks through their

association with the student teams. Note that these correlations, based on a small number of cases, should simply suggest areas that deserve further study.

To date, the economic impact of the demonstration is limited, as expected given the short period since it ended. Three client entrepreneurs reported that they are working 40 or more hours on their businesses. Two others are devoting 5-10 hours per week, and another characterized the hours as "many". Two individuals had hired employees, and one is currently advertising for a Program Controller position.

The story does not end here, however, and it will be several years until the real economic impact of the demonstration can be assessed. The client entrepreneurs still have a way to go before establishing their businesses, and even if that occurs, they have to survive a difficult economic climate. The U. S. Small Business Administration reports that 50% of small businesses fail in the first year and 95% fail within the first five years. Still, these unemployed individuals who were already feeling the effects of a struggling economy in 2001 were given a ray of hope and a chance to develop their product idea and explore the feasibility of starting a business of their own. Given the odds in business start-ups, the demonstration can be viewed as a success if even one or two of the fledgling businesses reach the point of hiring employees to produce, market, and sell the products developed by the student teams.

Notes

[1] See http://www.lehigh.edu/~inipd. For an academic article discussing IPD and its goals in more detail, see John B. Ochs, Todd A. Watkins and Berrisford W. Boothe (2001), Creating a Truly Multi-Disciplinary Entrepreneurial Educational Environment, *Journal of Engineering Education* 90(4).

[2] See http://www.lehigh.edu/~insbdc/index2.htm.

[3] See http://www.nep.benfranklin.org.

Figure 1. Service Model for Self-employment for Dislocated Workers, With Numbers of Applicant Progressing to Each Phase

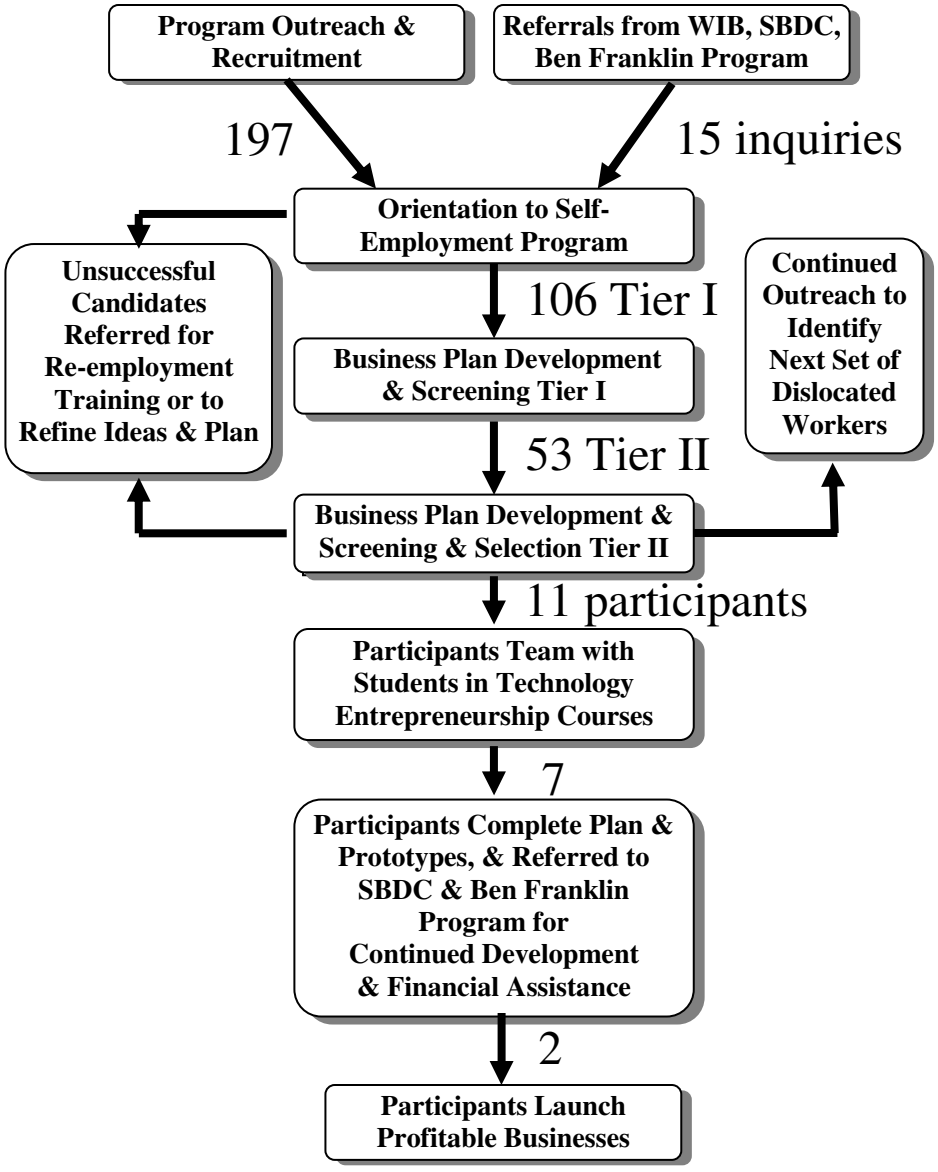

Table 1. Results of Survey to Rank the Influence of Characterisitics Associated with Successful Entrepreneurs.

Code: 5 = Extremely Influential; 0=No Influence

Description	Category Average	Average	N	Std. Dev.
Passion/Commitment	4.7			
level of commitment		4.9	50	0.35
passion about the idea		4.6	50	0.70
Knowledge of Market	4.6			
knowledge of the market		4.6	50	0.53
knowledge of customer needs		4.6	29	0.68
Product Characteristic	4.5			
market need		4.7	50	0.62
feasibility		4.4	49	0.89
Characteristics of Entrepreneur	3.7			
goal orientation		4.3	49	0.93
self-discipline		4.2	50	0.90
flexibility		4.1	49	0.66
risk tolerance		4.0	49	1.00
competitiveness		3.8	50	0.98
ethics		3.6	28	1.60
personality type/temperament		3.4	47	1.15
appreciation of the value of a dollar		2.9	29	1.54
internal locus of control		2.8	26	1.52
Skills of Entrepreneur	3.5			
decision-making skills		4.1	50	0.65
oral communication		4.1	50	0.81
leadership		3.8	49	1.03
strategic thinking		3.7	49	0.96
planning		3.7	49	0.93
time management		3.4	50	1.13
creating opportunity		3.3	26	1.47
ease with people		3.3	50	1.14
written communication		3.2	50	1.04
harvesting (conceptually)		2.3	25	1.52
Personal Conditions	3.1			
motivation for choosing entrepreneurship		4.0	49	1.15
work history		3.6	48	0.84
entrepreneurial/leadership experience		3.5	49	1.15
support of family members		3.3	50	1.21
financial status		2.7	49	1.14
educational level		2.6	49	0.89
family/acquaintances in business		2.2	47	1.27

Table 2. Checklist of tasks associated with starting a business

* = statistically significantly lower (at p<.10)

Task	Percentage of respondents completing the task: DoL Respondents N = 7	Unselected Applicants N = 9
1. Early Planning Stage		
Created a new product design	100	56*
Created a financial model	57	22*
Created a marketing strategy	86	56*
Created a business plan	57	33
2. Higher Level Planning		
Had the business plan critically reviewed and defended	14	11
Created a prototype	71	44
Tested a prototype	71	22*
Created a next generation design and prototype	43	11*
Created a production plan	43	11*
Created a marketing plan	71	33*
3. Early Business Activity		
Applied for funding	29	0*
Formed a legal business entity	71	0*
Applied for a provisional patent	29	11
Completed the patent submission process	29	11
Obtained a patent	14	11
Advertised to potential customers	57	11*
4. Business Launched		
Established office (home or elsewhere)	71	0*
Secured equipment/purchasing supplies	57	0*
Ramped up a production system	29	0*
Hired employees	29	0*
Started producing product	29	0*
Implemented marketing strategy	29	0*
Demonstrated product to potential customers	71	11*
5. Realizing Income		
Established paying customers	43	11*
Have positive cash flow	29	0*
Business is showing a profit	29	0*

Appendix. Example Page from Tier I Screening Instrument.

10. Is your product or idea presently being produced and sold by others?

No	[If "no", go to question 11].
Yes	[If "yes", go to question 12].
Don't know	[If "don't know", go to question 13].

11. **If you answered "No" to Question 10,** (your product/idea is not presently being produced and sold), please circle the appropriate response for the questions in this box. Then go to question 13.

	Not at All				A Great Deal
a. How well do you understand potential customers' needs and desires?	1	2	3	4	5
b. To what extent does your product or idea satisfy an unfilled need?	1	2	3	4	5
c. How certain are you that your potential customers are aware of the need for your product or idea?	1	2	3	4	5
d. To what extent have potential customers indicated a need for your product or idea?	1	2	3	4	5
e. How aware are you of specific locations of potential customers?	1	2	3	4	5
f. To what extent do you feel you will be offering the kind of products/service customers buy?	1	2	3	4	5

12. **If you answered "Yes" to question 10,** (your product/idea is presently being produced and sold), please circle the appropriate response for the questions in this box. Then go to question 13.

	Not at All				A Great Deal
a. How well do you understand potential customers' needs and desires?	1	2	3	4	5
b. To what extent will your product or idea serve an existing market in which demand exceeds supply?	1	2	3	4	5
c. To what extent will your product or service be competitive based on its quality, selection, price or location?	1	2	3	4	5
d. How aware are you of specific locations of potential customers?	1	2	3	4	5
e. To what extent do you feel you will be offering the kind of product/service customers buy?	1	2	3	4	5

13. Why will customers buy your product or idea?

5

14. Market Analysis: Customers

	No			Some-what	Yes
a. Do you know who your customers will be?	1	2	3	4	5

b. If your customers will be firms or distributors, list 1 or 2 possible customers:

_____

_____

c. If you will be selling your product or idea to individuals rather than to firms, for the typical customer, please indicate:

_____ Range of ages

_____ Gender

_____ Income bracket

15. Market Analysis: Competitors (Please circle the number that corresponds with your response.)

	Not at All			Some-what	Very Well
a. How well do you feel you understand how your business will compare with your competitors?	1	2	3	4	5
b. How well do you know your major competitors?	1	2	3	4	5

If you do know your competitors, answer the following questions for two of them.

Name _____

Product/Services _____

Strengths _____

Weaknesses _____

How will you differ? _____

Name _____

Product/Services _____

Strengths _____

Weaknesses _____

How will you differ? _____

6