A Case Study in Assessing Team-Based Project Courses: Lehigh University's IPD Program

John P. Ochs, Professor, Mechanical Engineering, Director Integrated Product Development Program, Lehigh University
Todd A Watkins, Associate Professor, Economics, Lehigh University
Drew Snyder, Adjunct Professor, Design Arts Program, Lehigh University
Jean Russo, Research Scientist, Center for Social Research, Lehigh University
Lisa Getzler- Linn, Administrative Associate, Integrated Product Development Program, Lehigh University

Abstract

In general, assessing the learning process is difficult because objective measures are not readily available, and the time needed to fully evaluate is considerable. This problem is perhaps exacerbated in team-based courses, where learning is unstructured in large part and the body of knowledge expected to be learned is variable. Additional issues that complicate assessment include cross-disciplinary teams, project variability and the involvement of external mentors including industrial sponsors, guest lecturers and consultants. Collaborative learning in team setting is beneficial to improving undergraduate science and engineering courses; however, no specific assessment tool has been used to evaluate its validity. As a result, novel techniques need to be developed to assess the value of team-based learning. This paper along with companion papers from the University of Delaware and John Hopkins University describe the experiences and lessons learned in assessing student performance in team-based, project courses.

Course/Program Vision and Objectives

The Integrated Product Development (IPD) at Lehigh University is a comprehensive integrated, cross disciplinary program that focuses on technical entrepreneurship through experiential learning. We use the new product development process as a means to the end of preparing our students to lead companies in innovation, creativity and the commercialization of intellectual property. Our mission is to develop a truly cross-disciplinary entrepreneurial environment and culture at Lehigh. The objectives of this mission are student and faculty focused and includes personal, inter-personal and professional development, curricula development and facilities development and implementation in support of both students and faculty. There are two main tenets of our program: 1) innovation, fueled by creativity, is the non exportable engine of local, national and global economic development, and 2) the greatest number of opportunities for innovation occurs at the intersection of disciplines. So our approach is to engage the entire campus community and attempt to impact the region, the nation and the world with our programs.

Course/Program Components

The depth and breath of the program are illustrated in the structure shown in Figure 1. The IPD program supports pre-college outreach through three annual courses: 1) The Career Awareness Program (CAP) for under represented high school students (Ref 1 and 2) the Manufacturing Expo with middle school students (Ref 2 and 3) the Pennsylvania

Governors School for Global Entrepreneurship administered through Lehigh's Iacocca Institute. The freshman project course has evolved to focus on students enrolled in Lehigh's Integrated Business and Engineering (IBE) program (Ref 3) and the freshman engineering experience. In Figure 1, the boxes marked "sequences" represent the support for curricula in the three undergraduate colleges. These sequences have included the new curricula in Design Arts, IBE, Computer Science and Business and Bio Engineering as well as support for individual established departments such as Management and Marketing, Mechanical Engineering and Materials Science (Ref 4). The Capstone courses are the culmination of student experiential learning where they work is cross disciplinary teams with faculty and graduate student mentors, as well with established companies, local start up companies and student entrepreneurs as project sponsors. Each year we have two courses for a total

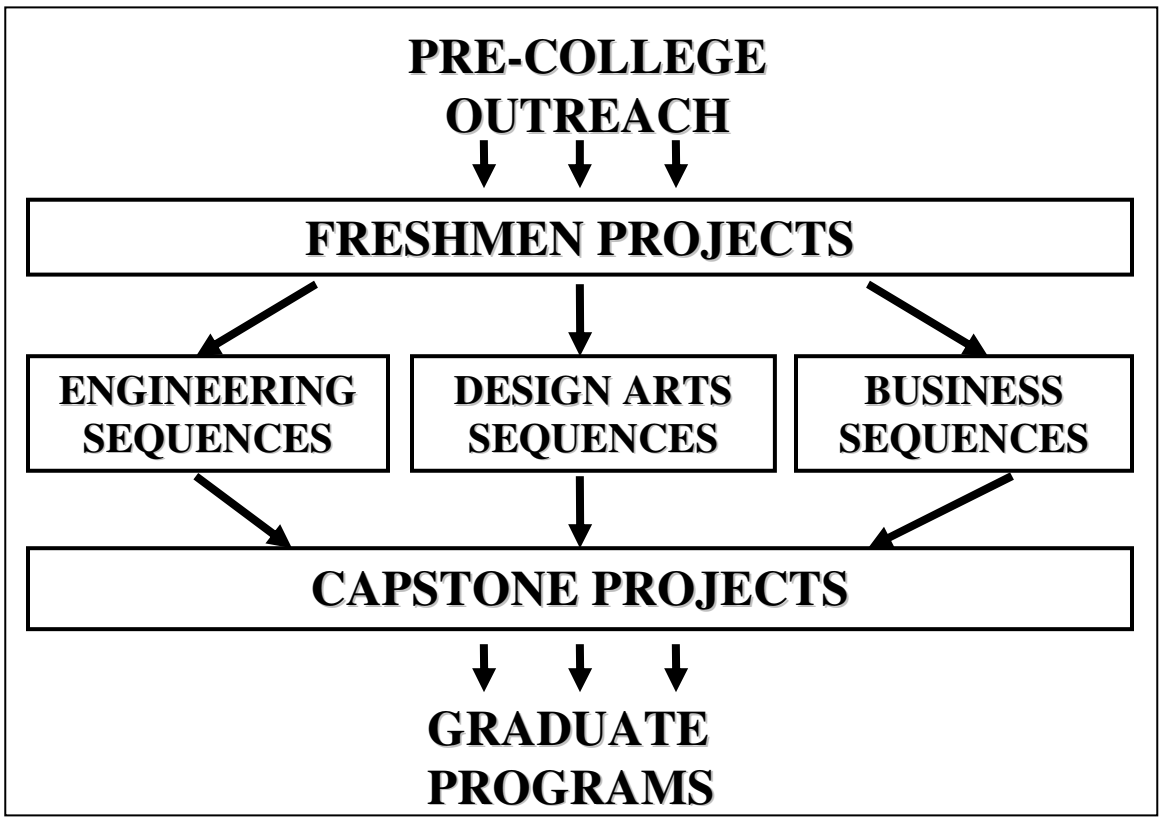

Figure 1. IPD Program Structure

of 5 or 6 credits that are co-listed under engineering business and design. For our 2003 project year (Jan 2003 – Dec 2003) 203 students, representing twenty majors worked in 34 cross disciplinary teams with 18 faculty advisors (Ref 5) The graduate programs are under development and currently include independent programs in the engineering and business, arts and science and our graduate college of education. The Business College's Ventures Series is part of the MBA program (Ref 6) and the IPD graduate course in Engineering focuses on new product development with a globally dispersed team (Ref 7).

This comprehensive program has taken several years to design, implement and develop scalable and sustainable infrastructure. It required global thinking with local implementation. More details of the lessons learned by a dedicated faculty implementation team can be found in Ref 8.

Course/Program Outcomes

In order to create an entrepreneurial environment for any and all majors from across Lehigh four colleges, the vision, goals and objectives, program components and outcomes have also evolved to be multi leveled. As shown in Figure 2, the components of a program can be summarized in one figure. While curricula and courses have explicit learning objectives that relate to ABET and other disciplinary-specific accreditation standards, the overall program assessment provides another integrating and comprehensive context for the assessments of individual curricula, courses, student performance, faculty, staff and facilities. This approach allows us to assess the readiness of our students for 'real world' leadership position in entrepreneurial enterprises that ,by necessity, are cross–disciplinary.

Methods of Assessment

Assessment should not be an end-of-process activity. Assessment should be part of the planning process. The development of the information shown in Figure 2 is a both the result of the planning process and an aid and consensus builder during the process itself. Our assessment methods included several approaches. On an annual and semester basis we have implemented the following: 1) internal, external and self assessment of student performance, 2) evaluation of courses, faculty, staff and facilities, and 3) internal and external assessment of the overall program.

<u>Assessment of student performance within various courses</u>

Various courses within programs that are affiliated with IPD, use a variety of student performance methods including self assessment, weekly contributions to the development effort, monthly tack board sessions, quarterly written reports, quarterly review of personal notebooks, quarterly peer evaluations, written and oral reports at the end of each course. The student performance is roughly distributed as 60% team grade shared by all and 40% individual grade.

Common among many courses such as Integrated Business and Engineering Freshman workshop, Engineering Freshman experiences, the IPD capstone courses, is the use of self assessment by the students of their knowledge before, during and after the course. Based on the learning objective, students rank their current level of knowledge of such topics as teaming skills and understanding of the product development process. An example self assessment is shown in Table 1 developed for the IBE 96, Freshman Workshop. For a typical class size between 35 to 45 students, the assessment can start at the first day of class with and expected outcome for most students of 1.0. At the end of the semester the expected outcome would be between 4 and 5.

Each week the IPD related courses require team meetings and reporting of progress as well as individual contributions. Weekly agenda and reports are required throughout the

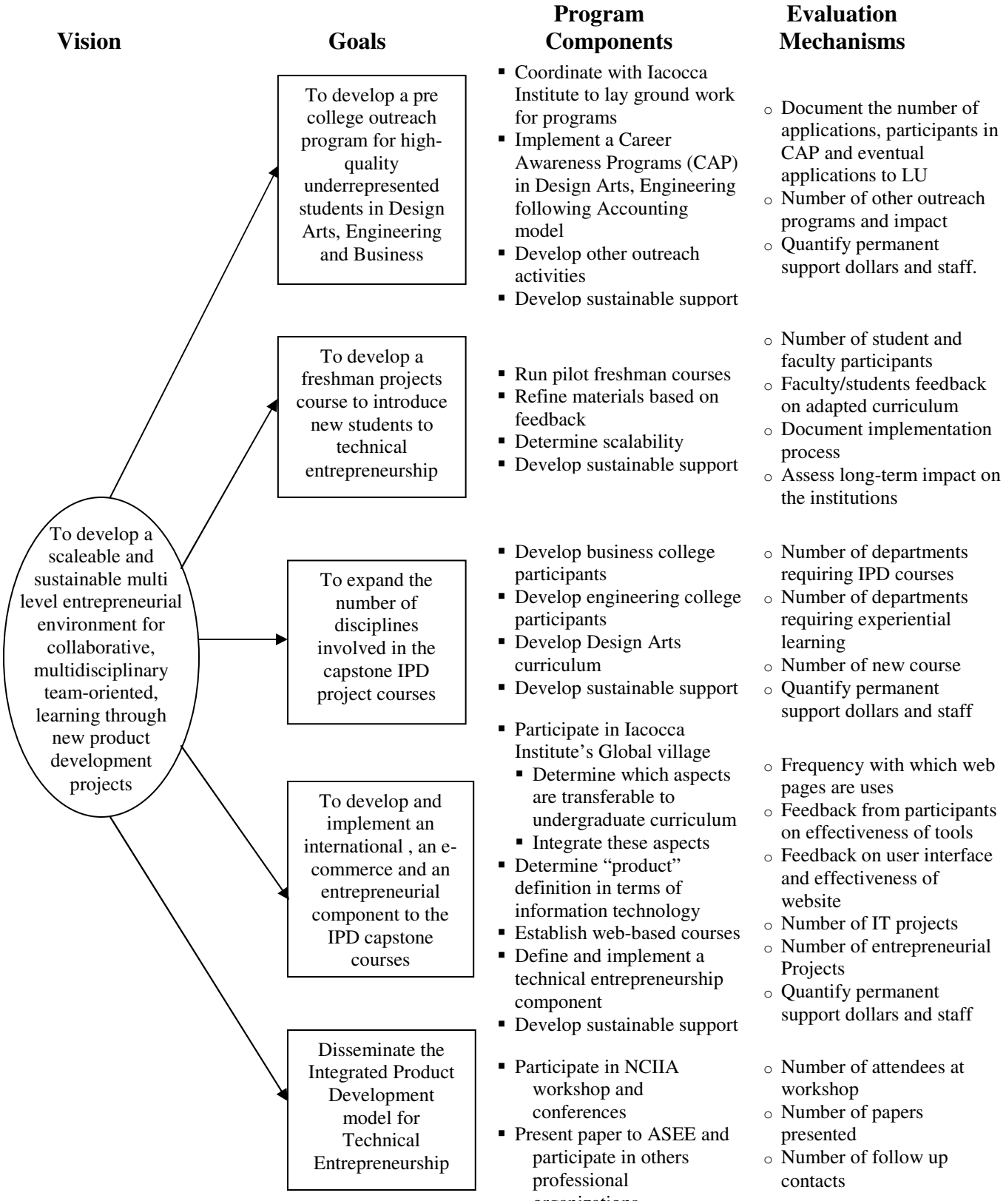

Figure 2. Evaluation Plan for IPD Model of Technical Entrepreneurship

semester. Typically during the first semester, team members are required to take on various roles, such as team leader, team scribe, financial manager and document manager. They must report on their progress as outlined in the course syllabus and tracked by a Gantt chart with key milestones. Depending on the curse at least twice during the semester, the teams must hand in their personal notebooks for authorizing and validating signatures from the faculty advisors and they receive a grade with comments.

As stated in the course objectives, currently I	Select 1 to 5 with 1 being the lowest and 5 being the highest ranking				
am more able to work in an interdisciplinary team of students from engineering to business	1	2	3	4	5
can more effectively communicate through oral and written and graphical presentations	1	2	3	4	5
have a clearer understanding of engineering and business practices in a competitive marketplace context	1	2	3	4	5
believe I could develop a simple business plan	1	2	3	4	5
am better able to identify and meet customer needs in business and engineering problem solving	1	2	3	4	5
gained a basic understanding of the role of major elements of businesses and their supply chains	1	2	3	4	5
can perform basic technical and financial feasibility studies	1	2	3	4	5
learned the basic skills needed to manage a team project including people and time resources	1	2	3	4	5
am better at defining and addressing open-ended, ill-defined problems	1	2	3	4	5
am more willing to ask questions of others to help me solve problems	1	2	3	4	5
have an introductory understanding of how to apply analytical, computer and physical modeling to engineering and business problem solving	1	2	3	4	5
better understand the role of market and engineering testing	1	2	3	4	5
will be a better engineer or business decision maker	1	2	3	4	5

Table 1. Self Assessment of current knowledge as related to the course objectives

Included in this deliverable is a peer evaluation with various categories of participation as well as a fictitious $10,000 bonus that each person on the team must distribute. Instructions and a blank peer review form are shown in Table 2 and Table 3 below. (This form did not originate here at Lehigh but has been slightly modified over the years. The original source of this form is not known to the authors.)

In additional to weekly progress report to the industry sponsor, there is a monthly tack board session that follows the design arts critique format. Each team must describe their development and defend their decisions and choices while receiving constructive criticism from the sponsors, faculty, staff and other students. Figure 2 shows a typical student team at a tack board session held each month during the academic year in the Wilbur Powerhouse, the campus hub for entrepreneurial projects.

Use these instructions and the Excel spread sheet (peer_evaluation_spreadsheet.xls):
Instructions:

Rate each team member (including yourself) with respect to the areas listed in each of the column headings.

Column one: Write the names of all team members (including yourself) in alphabetical order.

Columns A - I: Rate each member from 1 to 10 (1 being the lowest rating and 10 the highest rating) in each category. Enter "N/A" (not applicable) if a category does not apply to an individual.

Column Y: Enter the area (one of columns A through I) in which each member made his/her greatest contribution.

Column Z: Enter the share of a $10,000 bonus which you would distribute to each team member (including yourself) based on their overall contributions to the project.

In the last two lines of the table, for each column, put the name(s) of the member(s) who was most/least effective in that aspect of the project.

NOTES:

1. Individuals rarely excel in all aspects of the project work. A low score in some areas will therefore not necessarily result in a poor grade for you or your teammates.
2. In order to ensure that you have responded thoughtfully, consider filling in a copy of the form, waiting a day, and then reconsidering your entries before turning in your form.
3. This should be your own evaluation. It is not appropriate to discuss your evaluation with other team members.

These replies will be read only by your advisor and will be kept confidential

Table 2. Instruction for completing the peer evaluation form

In addition to the several drafts, a final report is submitted and becomes part of the team grade shared by all members of the team. A standard form is available on the course web site with suggested topics as listed in Table 4. In addition to the written report a 30X40 inch poster is required of each team. An example of an excellent poster, again from the Freshman IBE course is shown in Figure 3 (Ref 9). Each project team must present a final oral presentation and defense of their work at the end of each semester. This usually occurs during the final exam period at multiple locations through the Powerhouse.

Integrated Product Development {IPD}

Peer Evaluation Form

Team Member : _____

Project Title : _____

1	*A*	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*Y*	*Z*
Team Members	**Task Definition**	**Technical Contributions**	**Reports and Presentations**	**Prototype Fabrication**	**Finding Resources**	**Interaction w/Sponsor**	**Leadership**	**Teamwork**	**Ethical Conduct**	**Area of Greatest Contribution**	**Distribution of $10k bonus**
Most effective member(s)											
Least effective member(s)											

Please note below anything else indicative of your performance or that of any other team members.

Table 3. Peer evaluation form

Picture of October 2003, Tack Board session

Figure 3. A typical team "crit" session evaluating their monthly progress

Figure 4. An example poster from freshman workshop course

Project Background Section
Company Description (Size, core competencies)
Industry Description (Sector description, size, growth, major players)
Technology and Product Description
Management Section
Mission Statement
Project time line and milestones
Information and data management
Relationship management
Project team description
Business Section
Define the business opportunity
Describe the business strategy
Market Research: Analysis of Competition, Barriers to Entry
Market Plan: Target Markets, Market Segmentation and Differentiation Customer Profile, Pricing strategy and sales projections
Financial plan: Base case financial modeling, profit models, cash flow models, sensitivity analysis
Distribution channels
Sales and promotion
Financial plan: Base case financial modeling, profit models, cash flow models, sensitivity analysis
Distribution channels
Sales and promotion
Technology Section
Customer needs
Technical Specifications
Competitive Product Benchmarking
Concept Generation and Concept Selection
Product Architecture and Product Platform
Industrial Design
Final Product description: Assembly and system layout, CAD models, BOM, material selection issues, design for manufacturing and assembly issues
Cost analysis – fixed and variable costs, overhead and anticipated margins
Prototype fabrication – Differences between product design and prototype, fabrication issues, lessons learned
Prototype testing – features to be tested, test set up, test results, lessons learned
Production plan and costs – production layout, economies of scale, build versus buy decisions, supplier network, anticipated capital investments
Conclusion and Recommendation Section
Restatement of value proposition
"Go-no go and why"
Lessons learned

Table 4. Topics for final report

Evaluation of courses, faculty, staff, industry sponsors and facilities

At the end of each course, students have the opportunity to assess the course, the faculty, staff, industrial clients and facilities. Table 5 shows a sample evaluation form, in this case from the first capstone course which we have during the second semester junior year. In addition students are invited to participate in a session held at the beginning of the following semester. This session is usually run by a professional assessment person. The session is to identify the strength s and wishes for improvements in the previous semester's course. This has been well received by both the faculty and the students.

As an important part of the Department of Labor Grant to support local entrepreneurs to work with Lehigh student teams (Ref 10), the authors have developed assessment instruments particularly focused on the local entrepreneurs, faculty and staff. These include pre award readiness assessment of potential entrepreneurial clients and post assessment of the impact of their interaction with the student teams.

In the past 6 years the level of sophistication and the number of participants and projects have grown by about 20% each year. At the current rate we anticipant topping out at 50 teams of 6 or 300 students and 25 faculty advisors from across campus. This maximum number is based on the limitations of the Powerhouse to support these teams along with the availability of interested faculty. Even at our current level of 18 faculty advisors there is a need for consistency in expectation and grading across teams working on very different projects. To this end the authors have developed and will be continuing to develop a faculty advisors handbook and a series of rubrics to be shared by the faculty advisors. Table 6 in an example of the rubrics developed for aiding the various faculty advisors in assessment individual student's performance in three key areas of technical contribution, contribution to workload and resourcefulness and leadership and team work.

Overall program assessment

Annually the faculty, staff and industry sponsors assess the progress of the program to achieve its vision and identify lessons learned in the process (Ref 10). To this end additional rubrics have been developed. These are shown in Table 7. Based on the academic year ending in June 2003, the self assessment of the IPD program has been rated at 4.0 out of 5.0.

Evaluation of Assessment (Pro's and Con's)

Assessment is a pain and it is not easily done. The process takes time and valuable scarce resources. Also, it is new to most engineering educators. However, it is also extremely valuable. It is a key first step in continuously improving your courses, curriculum and programs. Developing the evaluation mechanisms as part of the overall planning of any activity, forces you to define what you mean and it is a visual tool to document your plan and build consensus.

We recommend that the assessment be used as what is it – a tool to gather information about the impact of what you are doing. It is not a mandate to change what you know is right. For example certain aspects of the program consistently get poor ranking on the

assessment for the course. These include the text book, the homework and the design notebook. The students consistently fail to appreciate the need and relevance of these activities. As experienced educators we need to remind ourselves that in many cases the students do not know what is good for them. Most students are ignorant of what it take to succeed in a profession and it is our job to teach them, set expectations of both behavior and performance. Nevertheless, the feedback is additional incentive to try to improve theses and all other aspects of the course, curriculum and program.

Another major issue when dealing with multiple cross disciplinary teams is consistency among the faculty advisors, who are the ultimate assessors via the grade. Setting expectations and quality goals require the development and implementation of standards. We are actively developing these and once again, it is not easily done. Implementing these can be equally difficult especially with faculty advisor who do not share a common set of expectations or who are "harder" or "easier" graders. In order to develop this commonality, we require that all first time faculty team with an experienced faculty member as co-advisors. While resource intensive, this has gone a long way to develop advocated for the cross disciplinary team approach to experiential education.

Conclusion and Future Plans

Assessment is here to stay. Embrace for it value. As any experienced educator knows the true measure of impact occurs many years after the course, the experience and the degree has been granted. This begs for longitudinal studies. In addition to exit interviews, we need to measure impact one, three and five years after graduation. This too requires a commitment of resources. However, the alumni association and the university development office are strong allies in this effort.

Finally, we are firm believers in the value of assessment. It is worth the expense. It is best done with both internal and committed external reviewers. Under the financial pressures we all face, there is a growing trend to eliminate or reduce the number of external reviews or reviewers or the frequency of reviews by so called external "visiting" committees. This is a mistake and the trend needs to be reversed. The benefits of the external input to the evaluation and assessment process, far outweighs the cost.

I learned a great deal in this course	1	2	3	4	5
The overall quality of the course was good	1	2	3	4	5
Overall, the instructors teaching was effective	1	2	3	4	5
The amount of work was appropriate for the credit received	1	2	3	4	5
I put in per week on average this many hours of work outside of class	1	2	3	4	5
The project had a successful outcome	1	2	3	4	5
I would recommend this course to other students	1	2	3	4	5
the weekly "crits" were valuable and pertinent	1	2	3	4	5
the homework was useful in learning the material	1	2	3	4	5
the weekly "crits" were valuable and pertinent	1	2	3	4	5
the homework was useful in learning the material	1	2	3	4	5
most helpful: least helpful:					
the instructors presented the material clearly	1	2	3	4	5
the faculty were available and interested in our learning	1	2	3	4	5
the instructors answered our questions clearly and concisely	1	2	3	4	5
grading procedures were fair and effective	1	2	3	4	5
I found the on-line course website useful	1	2	3	4	5
the personal/team notebooks were helpful in organizing the project	1	2	3	4	5
our team meetings were effective	1	2	3	4	5
overall, our team was effective	1	2	3	4	5
our work in the reverse engineering labs was productive and yielded a positive outcome	1	2	3	4	5
Faculty Advisor was available and interested in our project.	1	2	3	4	5
Faculty Advisor functioned as a valued member of the team.	1	2	3	4	5
Faculty Advisor was helpful when students were confused.	1	2	3	4	5
Faculty advisor treated the students with respect.	1	2	3	4	5
Our weekly meetings with the Faculty Advisor were effective.	1	2	3	4	5
Our weekly meetings without the Faculty Advisor were effective.	1	2	3	4	5
Interaction between the students and advisor was positive.	1	2	3	4	5
Sponsor-mentor was interested and involved in our work.	1	2	3	4	5
Sponsor-mentor had expectations that were reasonable.	1	2	3	4	5
Sponsor-mentor returned our phone calls & emails in a timely manner.	1	2	3	4	5
Our site visits were helpful and informative.	1	2	3	4	5
Our team was well balanced and multidisciplinary.	1	2	3	4	5
Our work in the MEM CAD lab was productive and yielded a positive outcome	1	2	3	4	5
Our work in the Arts & Architecture MAC lab was productive and yielded a positive outcome.	1	2	3	4	5
Our work in the Arts & Architecture Prototype lab was productive and yielded a positive outcome.	1	2	3	4	5
The student lab was available and user friendly for our purposes.	1	2	3	4	5
The IPD administrator played a valued role in our team's management.	1	2	3	4	5
The IPD outreach manager played a valued role in our team's progress	1	2	3	4	5

Table 5. Student Assessment of course, faculty, staff industry sponsor and facilities

Table 6. Individual Contribution to Team Effort -- Peer and Faculty Evaluation

	Technical Contribution	Contribution to Workload / Resourcefulness	Leadership & Team Work	Professionalism & Interaction with Sponsor
1	Individual offered very little sound and useful technical guidance toward the project. Quality of work done by individual was generally unsatisfactory and had to be revised regularly by other team members.	Individual did not take initiative or make much effort in tackling a fair share of the workload. Individual was often complacent to let others do the majority of the required work.	Individual did not assume a role of leadership in any aspect of the project. Individual resigned to following along with the general consensus of the group in both technical and planning issues. (or) Individual's contribution to the team was counterproductive.	Individual's level of professionalism and maturity in interacting with the project sponsor, team members, faculty, IPD staff, or others was unsatisfactory. Individual's ability to communicate effectively, professionally, or appropriately with those mentioned above or outside contacts for research detracted from his/her ability to carry out necessary responsibilities.
2	Individual's overall contribution was somewhat limited (less than other team members') in either relative quantity or quality. (or) Individual often dwelled on issues which deviated from a relevant and focused solution.	Individual followed through with his/her agreed upon share of the workload, but often by either doing just the minimum for satisfactory quality or regularly completing assigned work late. (or) Amount of work individual handled was not enough.	Individual reluctantly accepted assuming leadership in minor aspects of the project. (or) Individual's ability to lead the group on any level was either not highly efficient or not highly effective. (or) Individual's interaction with the team did not contribute significantly toward the team's success.	Individual's level of professionalism and maturity was satisfactory. Individual's confidence level in interacting with others outside the team may have slightly limited his/her success in carrying out responsibilities.
3	Individual's technical contribution was satisfactory or better and at least in line with that of other team members. Individual contributed at least some useful original thought and technical guidance for the project.	Individual carried out his or her agreed upon portion of the work well and on time. Individual exhibited initiative and ingenuity in his or her work.	Individual willingly took on a leadership role and did so efficiently and effectively. Individual's interaction with the team was positive and contributed significantly toward the team's success.	Individual's level of professionalism and maturity was satisfactory. Individual's confidence level in interacting with others outside the team was more than satisfactory for the individual to effectively handle his/her responsibilities.
4	Individual's technical contribution set and maintained the course of the project. Amount and quality of contributed work was excellent and/ or significantly above that of other team members.	Individual carried out his or her agreed upon portion of the work well and on time. Individual took on a disproportionately large portion of work & should be credited accordingly.	Individual inspired the vision of the team, nurtured a team harmony, and took on a role as a natural leader. Individual's ability to guide the progress of the project and delegate responsibilities was paramount in project's success.	Individual's level of professionalism and maturity was exemplary. Individual was able to foster a positive professional relationship with others outside the team who were involved in the project, which added greatly to the success of the project.

		Table 2. Overall Program Rubric				
	Educational Objectives	**Constituents**	**Processes**	**Outcomes Assessment**	**Results**	**System**
1	Not well defined	Informal contact	Few, if any processes defined and documented	Limited to ad hoc efforts	Anecdotal	None evident
2	Broadly defined and documented:clearly tied to mission; evidence of constituent input	Somewhat involved in defining objectives and desired outcomes, and assessment	Some major processes defined and documented; clearly tied to mission and program objectives	Some outcomes defined and improved in systematic manner; problems recognized and corrected	Satisfactory outcomes; some evidence of positive trends in areas deployed	Early stages; partial deployment within the program and college
3	Comprehensive; defined, documented' and measurable; clearly tied to mission and constituent needs	Clearly involved in defining objectives and desired outcomes, and assessment; evidence of some sustained strategic partnerships	Processes for all major elements of criteria defined, documented, and controlled; clearly tied to mission, program objectives, and constituent needs	All major outcomes defined; systematic evaluation and process improvement in place; problems anticipated and prevented	Good outcomes; positive trends in several major areas; some evidence that results caused by systematic approach	In place; deployed throughout the program and college; driven by mission and objectives
4	Comprehensive; defined, documented and measurable; clearly tied to mission; responsive to constituent needs; systematically reviewed and updated	High degree of involvement in defining objectives and desired outcomes; evidence of many sustained strategic partnerships in all constituent groups	Processes for all elements of criteria are quantitatively understood and controlled; clearly tied to mission, program objectives, and constituent needs	All outcomes defined; systematic evaluation and process improvement in place; many support areas involved; sources of problems understood and eliminated	Excellent outcomes; positive trends in most areas; evidence that results caused by systematic approach	Integrated; deployed throughout the program, college and support areas; driven by mission and objectives
5	Comprehensive; defined documented, measurable and flexible; clearly tied to mission; readily adaptable to meet constituent needs; systematically reviewed and updated	High degree of involvement in defining objectives and desired outcomes, assessment; and improvement cycles; sustained evidence of strategic partnership with all key constituents	Processes for all elements of criteria are quantitatively understood and controlled; clearly tied to mission; program objectives, and constituent needs; seen as benchmarks by other institutions	All outcomes defined; systematic evaluation and process improvement in place; all support areas involved; common sources of problems understood and eliminated	World-class outcomes; sustained results; results clearly caused by systematic approach	Sound, highly integrated system; deployed throughout the program, college, and institution; driven by mission and objectives

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