AC 2008-1253: A DECADE OF UNIVERSITY SPORTS FACILITY DESIGN COURSES

Michael Collins, J.P. Morgan Chase

Michael G. Collins is a first-year analyst in J.P. Morgan Chase's Management Services Program where he will rotate between 4 different branches of the bank. He is a January 2008 graduate of Lehigh University earning both a B.S. in the Integrated Business and Engineering Honors program as well as a B.S. in Industrial Engineering. Michael has participated in 3 different courses at Lehigh which utilized a project-based curriculum to partner students with outside clients. In the Integrated Business and Engineering Capstone Project he worked with Online Staffing Solutions of Allentown, PA. In the Industrial Engineering Senior Project he worked with Fragrance Manufacturing Incorporated of Bethlehem, PA. Michael was also a member of the Integrated Learning Experience during fall 2007 which provided consulting on Lehigh's master plan for their athletic campus.

Gerard Lennon, Lehigh University

Gerard P. Lennon is Professor of Civil and Environmental Engineering and Associate Dean of the College of Engineering and Applied Science. He earned a BS from Drexel University, and an MS and a PhD from Cornell University. He authored over 70 papers, and his groundwater research has been funded by five different federal and state agencies, including an NSF investigation of ocean-bottom geothermal vents in the Alvin Submarine. As a member of the American Society of Civil Engineers he organized an International Groundwater Symposium and was an associate editor of the Hydraulics Journal. He has supervised civil engineering students in interdisciplinary design projects of Lehigh sports facilities from 1998 to 2005.

John Ochs, Lehigh University

John B Ochs is Professor of Mechanical Engineering at Lehigh and Director of the Integrated Product Development Program (IPD), which he co-founded with Dr. Watkins in 1994. He is the past chairman of ASEE's Entrepreneurship Division. From 1985-95 Dr. Ochs did extensive industry consulting and was involved in the start up of three companies. In 1996 the pilot courses IPD won the American Society of Mechanical Engineers' curriculum innovation award and in 1997 IPD won the Newcomen Society award for the promotion of America's free-enterprise system. Dr. Ochs holds a MS and Ph.D. from The Pennsylvania State University. He often supervised mechanical engineering students in interdisciplinary design projects of Lehigh sports facilities.

Richard Weisman, Lehigh University

Richard Weisman is Professor of Civil and Environmental Engineering at Lehigh and served as Associate Dean for Undergraduate Programs for 11 years, finishing in 2006. His teaching and research is in the field of water resources engineering with concentrations in surface water hydrology and sediment transport. He has been leading interdisciplinary groups of students abroad through several programs, including a winter term course on Sustainable Development to Costa Rica. He is co-advisor to Lehigh's chapter of Engineers Without Borders which is involved in a water supply project in a small town in Honduras. In addition to supervising the civil engineering students athletic facility design projects in 2006 and 2007, he eagerly served as a source of help in the first eight years to those students interested in the drainage and runoff issues pertaining to several of the past projects.

Vincent Munley, Lehigh University

Vincent Munley is Iacocca Professor of Business and Economics at Lehigh and is the university's Ombudsperson. His research is directed at the empirical study of public policy issues, in particular topics related to fiscal federalism. He earned a B.A. in economics and a B.S. in

© American Society for Engineering Education, 2008

electrical engineering from Lehigh University, and Ph.D. in economics from the State University of New York, Binghamton. He spent a semester as a Fulbright Scholar at the National University of Ireland, Galway. For ten years he has team-taught with Dean of Athletics Joe Sterrett a course on the economics of the sports industry and has helped guide ten student teams and two summer internship teams involved in cross disciplinary sports facility design projects.

Joseph Sterrett, Lehigh University

Joe Sterrett is the Murray H. Goodman Dean of Athletics, currently serving in his 19th year as the director for intercollegiate, club, intramural and recreational sports programs. He earned a bachelors degree in Finance and Social Psychology, a Masters degree in Educational Administration from Lehigh and a Doctor of Education degree from Temple. At Lehigh he has served as an assistant football coach, director of undergraduate student recruitment, and assistant vice president for enrollment management. With Professor Vince Munley, he has team-taught a course on the economics of the sports industry and has led 11 student teams and two summer internship teams involved in cross disciplinary sports facility design projects.

© American Society for Engineering Education, 2008

A Decade of University Sports Facility Design Courses

Abstract

Every fall over the last decade, interdisciplinary undergraduate student teams have designed athletic facilities for the Lehigh University campus. This initiative comprises part of the Integrated Learning Experience (ILE) program. The paper focuses on the procedures of this excellent model used to provide a real-world context for students to achieve academic objectives and learning opportunities of cross disciplinary undergraduate education, not otherwise available for many of them.

The distinctive aspect of these designs is that they comprise a very utilitarian component in the ongoing planning for improvements to the university's athletic facilities, some being initial feasibility studies, and some slated for construction. Procedures used to select realistic projects and establish the university as a "real" client are reviewed, as are the requirements of the presentations and deliverables so that they can be used for an implementation decision by the appropriate client representatives (alumni donors, faculty, student athletes, and staff such as sports coaches and the Associate Vice President for Facilities Services and Campus Planning). The process of involving faculty and recruiting and selecting students is explained, along with creating an atmosphere of excitement and desire to be included.

The first facility built was the 1998 design of a 2000-seat stadium for field hockey, lacrosse, and soccer, which included a student presentation of the proposed $2.4 million facility to the university Board of Trustees for approval. The latest is a nine-hole golf course, club house, and driving range currently under construction, evaluated by the university clients. The annual course is led by Drs. Joseph Sterrett, Dean of Athletics, and Vincent Munley, Professor of Economics, with faculty supervisors from each of the students' home departments. The projects have focused on the following sports, some in multiple years as indicated: crew, cross country (2), softball/baseball (2), field hockey, lacrosse, soccer, tennis, and golf (3).

Just like consulting teams working in the private sector, student teams were composed of members with diverse backgrounds in order to address complex challenges. The student teams have included majors from all three of Lehigh's undergraduate colleges and the following departments: accounting, architecture, Asian studies, civil & environmental engineering, economics, English, finance, journalism, marketing, earth & environmental science, industrial engineering, mechanical engineering, chemical engineering, computer engineering, electrical engineering, integrated business and engineering, history, international relations, management, psychology, statistics, supply chain management, and urban studies. The real world atmosphere stemmed from the realistic teaching and learning challenges of interaction with the clients, government approval agencies, and other experts, all of whom reviewed, evaluated, and assessed the presentations and reports.

The value of the course for students includes interacting with entities outside of the university in a real world situation. Student presentations were evaluated and assessed by instructors, other university faculty and staff, alumni, including potential donors, and varsity team coaches. A more formalized assessment program is recommended for future courses. The students have found this experience to be one of their most valuable and memorable of their undergraduate career, documented by the fact that most have reflected on their ILE experience in answering questions during job or graduate school interviews.

This paper provides guidance and experience on how to create a sustainable annual course on a limited budget, rather than presenting detailed results of the investigations. A case study of a multiyear investigation describing the actual details and providing results of a project for a golf facilities is available and complements the current paper.[1]

I. ILE Overview and Course Philosophy

In 1997 the Lehigh Earth Observatory (LEO) began conducting a land use analysis for a parcel of Lehigh University property that the university was planning to sell. The economic and environmental surveys were conducted by a group of 13 Lehigh University students with a wide array of majors and under the direction of Drs. Carl Moses (Earth & Environmental Sciences) and Vincent Munley (Economics). Faculty supervisors from each of the departments were invited to work with the instructors. The group was successful in completing a wetland analysis, geotechnical analysis, and a cost/benefit analysis for the area through field experimentation and zoning restriction research. In their final report, the group recommended that development of the land had potential benefit for all parties involved with minimal risk and was environmentally safe to pursue. A number of faculty members provided guidance and attended the student presentations, including Prof. Lennon from Civil and Environmental Engineering.[2]

Dr. Munley immediately recognized the potential that similar projects held in educating students while potentially benefiting the university. Working with Dr. Joe Sterrett, the Athletic Director at the time, the two structured an elective course that would allow students from all three undergraduate colleges to collaborate and solve problems facing the Goodman athletic campus. The 600-acre Goodman Campus currently houses a football stadium, a basketball arena, a cross country course, a running track, a field house, multiple tennis courts golf practice facility, and softball, baseball, field hockey, and lacrosse fields as well as numerous practice fields. Some of these facilities have been built based on ILE designs. Civil Engineering students are able to use this course as an approved (technical) elective to complement, but not replace, the required capstone design course (CEE 290).

Beginning in fall 1998 with the first ILE course, 13 students were recruited to design a sporting venue that could be used by soccer, field hockey, and lacrosse. The students' charge was to design a facility with two fields (one grass and one artificial turf) to serve the needs of all the teams, spectators, and university personnel. The students' recommendation was an original design which included a stadium with seating between

the fields, which minimized the facility's footprint and centralized spectators, reducing the need for additional restrooms or ticket counters. The unique design required students to demonstrate that the structure was structurally sound before presenting the proposal to the Lehigh University Board of Trustees, who approved the $2.4 million project. The project has been completed and has received acclaim for its innovation in a short article in the February 1999 issue of the American Society of Civil Engineers Magazine.[8]

The ILE course has evolved to tackle projects surrounding the cross country course, a crew/boat house, a golf facility, a softball/baseball complex, and the tennis facility. Some of these projects have been investigated in multiple years as seen in Table 1, including the Goodman Athletic Campus Master Plan which was studied the last two years and includes additional parking lots, traffic improvements, the location of athletic fields, GIS surveying, and the location for a new entrance sign to the campus.

While there have been many significant achievements made through the ILE course, this paper focuses on the processes of creating a teaching environment for a course of this nature rather than the success and failures of each individual year. Copies of the individual project reports cited in this paper and the remaining ILE projects are available from the instructors and copies are kept on file in the Athletic and Civil Engineering Department Headquarters.[2, 3, 4]

Table 1: List of Projects and faculty and students involved annually in the ILE projects

Year	Number of Student Projects	Facilities Involved	Number of Student Teams	Number of Students Involved	Number of Different Student Majors*
1998	1	Dual Field Complex	1, 8 sub	13	5
1999	3	Baseball, Cross Country, & Living Lab	3, 8 sub / per project	37	11
2000	1	Golf	1, 8 sub	9	6
2001	1	Crew Boathouse	1, 6 sub	8	4
2002	1	Tennis	1, 8 sub	9	5
2003	1	Golf	1, 6 sub	9	7
2004	1	Baseball/Softball	1, 7 sub	13	10
2005	1	Golf	1, 8 sub	14	10
2006	1	Master Plan	1, 6 sub	14	10
2007	1	Master Plan	1, 7 sub	12	10

* Some students were completing double majors

II. Course Design

A. Learning Objectives

The fundamental purpose of this course is to educate undergraduate students to be successful in their endeavors upon graduation and enhance their overall college experience. This course is structured to ensure that upon completion of this course the student should be able to[1]:

1. Work effectively as a member of an interdisciplinary project design team, bringing unique skills, perspectives, and background not shared by all team members, and using information provided outside the student's own background to complete the design.
2. Design a sports facility including the evaluation of considerations such as economics, ethics, societal, environmental impacts, and constructability.
3. Write a project report that is of a quality commonly found to be acceptable in the engineering profession.
4. Orally present the results of an engineering design project to a wide audience of students, faculty, staff, including coaches and student athletes, using a presentation package such as PowerPoint that is of a quality commonly found to be acceptable in the engineering profession.

B. Project Selection

The process of selecting feasible projects is especially crucial to the success of the course. They must present workable alternatives to real projects while also allowing students a degree of freedom to suggest creative solutions for the university's long-term vision for the entire campus. In addition, it was found that a single project is preferable each year because it would become increasingly hard to find multiple new, interesting and feasible projects each year.

Each year the instructors review the current sports facilities and the projected needs of the athletics department before selecting a topic for the next ILE course. Instructors also review any new suggestions from the Lehigh community, as well as recommendations made from past ILE projects. For example, in the spring of 2007 the Student Senate recognized the importance of building an entrance sign on the Goodman Campus, which lacks a clear indication to visitors that they have arrived at Lehigh University. The lack of a sign became important enough to the student body that the issue was not only taken to the university president but was also voted by the class of 2008 as their intended class gift. The 2007 ILE team designed and proposed a location for the sign which is now pending approval from the class of 2008 and the university.

The relative size of the project should not be a deterrent during consideration. While smaller scale projects allow for a more detailed assessment and final recommendation at the end of the semester, larger projects can also be undertaken. When a topic is presented to the students at the beginning of the semester, it is up to them to set their deliverables so they are not only achievable but can also be built upon by future groups. These deliverables must be approved by the advisors, and checked periodically, to make sure students are setting their sights high, but not out of reach. The golf facility is an example of how a large project was studied three separate semesters by focusing on different aspects of the project each semester.

Another alternative on how to handle larger scale projects is for some sub-groups to start work prior to the beginning of the fall semester, and receive credit during the summer.

For example, prior to the first softball/baseball complex study, a team of civil engineering students surveyed the entire site and created AutoCAD drawings so that the other sub-groups could be productive at the very beginning of the semester. Some students have also opted to continue to work on specific recommendations made by their group through independent studies in the following spring semester, although this option is typically left up to their faculty advisor.

C. The Student Team: Size and Selection

While the size and scope of the projects selected for the course should not be a limiting factor, picking the proper size of the class was important. The popularity and success of the ILE course in its first year in 1998 created a lot of interest from the student body and a high demand for a limited number of spaces. In response, in 1999 the instructors and advisors attempted to run three projects, two sports complexes and one "living lab," each having 8 sub-groups.

However, because these ILE courses are largely an addition to normal teaching duties of the faculty supervisors, they had difficulty providing teaching, leading, and advising of 37 students in a timely manner without funding for release from other duties. Thus after the second year, a single project with ten to fifteen students in about 8 sub-groups was selected as the sustainable model and was used for the next eight years.

Interested students are informally interviewed by a course advisor, or provided a written statement, to become aware of the required commitment level and to explain their reasons for wanting to take the course and what skills they have to offer. The advisors then selected the students based on interviews, statements, and the number of students needed in each major to create a balanced team to address all of the facets of the project.

The projects are composed of separate tasks each year and therefore required a specific skill set. All projects over the past decade have required significant expertise in civil engineering and economics because the project tasks are planned as real world projects on actual sites, usually requiring an initial land survey and cost analyses. In addition, the course instructors have recognized the importance of the quality of the final report and have made an effort to recruit interested journalism and English majors to the team. A complete breakdown of student majors by year can be found in Table 2.

D. Role of Advisors

The role of the advisors is crucial to the success of the ILE course. They sometimes act as a resource themselves or help identify other resource people, but their main task is to guide the students, maintaining a balance between giving advice and empowering the students. One of the distinct characteristics of the ILE course compared to most other project-based courses is that students are free to determine the direction their project takes by setting their own deliverables with limited guidance from the faculty. In other project-based courses like Capstone Design or Integrated Product Development (IPD) students are partnered with outside firms and asked to explore and analyze a particular

alternative or option for the firm. While this process may give students more focus and an idea of what is expected from them it can also stifle creativity. The ILE course empowers its students by leaving all the decisions up to them but relies on the judgment of its advisors to oversee this process and intervene when necessary.

It is extremely important that the advisors have a good working relationship with other university faculty and staff, because the student teams meet with many different university staff members to research their projects. In some cases it was difficult to arrange meetings with staff members who are busy. Advisors with strong relationships with university faculty and staff can promote these projects and encourage staff and vendors to participate, which significantly benefit the student teams. Also, the entire community had learned the value of the ILE sports complex course, through word-of-

Table 2: Breakdown of student majors by year of participation

	1998	1999*	2000	2001	2002	2003	2004	2005	2006	2007	Total
Majors											
Civil & Environmental Engr	1	6	3	3	3	4	2	4	5	4	33
Economics	4	2	4	3	4	3	5	2	2	1	30
Architecture		3	1	1	1		2	2		2	12
Earth & Environmental Science	8				1		1		1	1	12
Journalism						1	1	1	1	1	5
Accounting		1				1		1		1	4
Finance		1						1	1	1	4
International Relations			1			1	1	1			4
Marketing	1	1			1	1					4
Mechanical Engr		2		1				1			4
Industrial Engr							1		1	1	3
Psychology							2	1			3
Computer Science		2									2
English		1	1								2
Electrical Engr		2									2
Integrated Business and Engr							1			1	2
Supply Chain Management								1	1		2
Environmental Engr							1				1
Management									1		1
Urban Studies									1		1
Asian Studies									1		1
Chemical Engr			1								1
Computer Engr		1									1
History						1	1				2
Statistics										1	1

*Of the 37 students in the ILE course in 1999, 20 participated in sports complex design and are included in the table. The rest participated in the "Living lab" project, not directly related to sports facilities, and are not included in the table.

mouth, presentations and many articles in the student newspaper, all of which has contributed to a high degree of willingness of staff to take the time out of their busy schedules and help students.

In almost all 10 years, at some time the course instructors and faculty advisors have had to walk a fine line in project management issues, choosing between three basic options:

1. Let students work out the issues with possible detrimental effects to course or deliverables
2. Provide limited executive decisions to positively affect the outcome(s)
3. Weigh in heavily and interrupt the interactions that might (or might not) work themselves out in a timely manner by the students

Such decisions are difficult at times, and Option 3 will typically result in meeting deadlines but with a less valuable student learning process. The faculty instructors encourage groups to reflect on situations afterward and to appreciate the positive educational aspect on the overall project when Option 1 was used and deadlines are missed.

III. Typical Team Activities

To provide insight on how the student teams operate with limited guidance two past projects are discussed, the 2005 golf design project and the 2007 master plan project. Additional details of the golf facility design can be found in Reference 1.

A. Team Structure

From the first day the project is presented, students are advised to attack the project by dividing into sub-groups that will focus on different aspects of the project. While the formation is left to the students, typically there are 6 to 8 sub-groups (Table 1) each having 3 to 5 members. Students generally participate in two sub-groups, one that directly pertains to their major and another of interest to them. Each sub-group nominates a contact person to serve as the project manager.

The number and types of sub-groups are different for each year and project as the focus of the team changes. For instance, the 2000 Golf Project sub-groups were site survey, soil analysis, site development, architecture, technology, executive course, and cost-benefits/revenue, while the 2005 Golf Project sub-groups included project management, market research, pond design, irrigation design, clubhouse design, pricing strategy, cost analysis, and a report group. Students have also been encouraged to create a sub-group for the project management of the entire team to keep the students on pace to meet their deliverables. This group is responsible for setting and running weekly meetings as well as acting as a central point of contact for the advisors and team members.

The advisors often stress that meeting minutes and decisions must be included in the final report. Some teams created a separate sub-group to oversee this activity in 2007, and some other years, students decided to include this in the responsibilities of the project management group. New technology has made this process easier; for example students

are provided with Teaching Assistant privileges on a course Blackboard account. Separate folders are created for the deliverables of each sub-group. This system allows for students to post and organize documents, such as meeting minutes and AutoCAD drawings, to a central repository where information is readily available to all participants and can be compiled into the final report. Blackboard also contains email distribution lists to ease communication as well as features to track member attendance at meetings or the number of times they access Blackboard each week to help both peers and advisors monitor individual participation.

B. Team Activities

Sub-group meeting times and format is mostly left up to the students to determine with guidance from the advisors on best practices. The advisors typically meet with sub-groups one hour each week. Students often ask questions or get feedback from the advisors on their ideas. This approach also allows the advisors to judge whether or not to step in and benchmark their deliverables to the historical performance of past groups. At this meeting the project manager for each sub-group updates the entire team and advisor(s) on completed tasks during the course of the week and details the deliverables for the following week. Appendix A provides an example of a progress report used by the 2007 ILE team. This system has proven to be effective for the ILE course and was based on the IPD program[6].

At the weekly meeting, the advisors often suggested particular faculty or staff members who could be contacted for additional information. For example, the 2007 Master Plan team students reported that they were ready to survey the student body the following week. However, the group had not received permission (nor were they aware that they needed to) from the university to conduct a survey and at this meeting the team was advised on how to continue and who is authorized to grant permission.

The members of the 2007 team met for a minimum of two regularly schedule meetings each week outside the meeting with the course advisors. The team met as an entire group on Tuesday evenings to discuss the direction of the overall project and determine what is needed from each sub-group. Individual sub-groups also met at conveniently scheduled times, creating plans to meet with faculty or staff representatives and collaborate to finish their deliverables for the week.

C. Challenges

The most common group interaction challenge, and important learning opportunity, during the past 10 years has been when one sub-group misses a deadline for providing information another sub-groups, who in turn can not complete their task(s). Two options for reducing the students' tendency to procrastinate are (1) to hold team meetings in a formal setting (i.e. conference room instead of a student lounge) and (2) to record in the meeting minutes what members agree to complete by the next meeting. First, an agenda is distributed with planned accomplishments by that date. Each member has 20 seconds to quickly state their progress toward those accomplishments. By holding each student individually accountable for their efforts, overall productivity of the team increased.

Another challenge associated with time management is finding common free time for the entire group and more importantly, individual sub-groups. With many students involved in activities such as varsity athletics, club sports, student organizations or work study jobs, it was difficult to find common meeting times, especially nearing the conclusion of the project. Students often had to make sacrifices to attend group meetings, and learned to juggle many demanding activities and have to set priorities. Likewise, the group has to be able to continue to function if members are late to meetings or cannot make it at all. To deal with these situations, the 2007 team posted meeting agendas on Blackboard the night before their meetings so members could plan ahead and give the appropriate weekly material to someone else if they were unable to make the meeting. Detailed schedules of all students' semester activities were compiled on Blackboard so that common available meetings times were considered when creating the sub-groups. This process typically relieves pressures later in the semester.

While time management is extremely important, the group must also balance deadline requirements while leaving time for creative thought. In 2007 the ILE team was charged with designing a new entrance sign for the Goodman Campus. The sub-group in charge of the initial design researched area colleges and online photos of entrance signs at other campuses. Faced with a fast approaching deadline of presenting AutoCAD renderings, the sub-group selected a few of these traditional designs to mock-up in AutoCAD. Even though initial feedback came back that the proposed designs lacked ingenuity and did not necessarily capture the spirit of Lehigh, the group moved forward with their ideas to meet the next deadline. By the end of the semester the group regretted not spending more time brainstorming in the initial phases to create a unique design because they were too focused on meeting the next deadline and moving the project along.

D. Presentation and Feedback

Every semester the ILE team is required to submit a final project report with all findings, research, analysis, and recommendations. The detail and explanation in the report is extremely important, not only to document the work that the team members have completed but to serve as a basis for future ILE groups who may extend the project. Keeping this in mind, students are asked to recommend additional areas of future work as well as lessons learned from the overall course experience. A popular one is that students wished they had started preparing for their final report earlier because they did not recognize the amount of effort it would take to prepare.

In addition to the final report, the students give a final presentation to the advisors and invited members of the Lehigh University family who may have a vested interest in the project. A required mid-term presentation is critical for practice for the final presentation and to obtain feedback from the guests. It is important that the students realize that guests are not criticizing the students or trying to diminish their work, but rather offer advice or insight. During the midterm presentation in 2007, the group was asked about their proposed location of the entrance sign with regards to the nearest utilities needed to power the lights. Instead of admitting that the issue was not considered, the members tried to sidestep it and defend the original location. For the students to get the most out of

the feedback sessions they must be able to admit to themselves and their audience that they may not have considered all possibilities. Reflection on this type of decision contributes to the learning experience.

Several projects were so successful that the university continued with the development and analysis and took the concept to the next level. The golf and baseball/softball teams were asked to present their findings to other members of the university and the 1998 dual-venue stadium presented their plan to the Board of Trustees.

IV. Meeting and Exceeding ABET Requirement

How the ILE course helps programs meet and exceed ABET criteria is summarized along with a review of the assessment and evaluation methods used and to recommend new assessment methods in future ILE sports courses to improve assessment.

A. ABET Accreditation Requirements

ABET, Inc. is the recognized organization responsible for accreditation of over 2700 education programs in applied science, computing, engineering, and technology at over 550 colleges and universities in the USA. Accreditation (1) helps students and their parents choose quality college programs, (2) enables employers to recruit graduates they know are well-prepared, (3) is used by registration, licensure, and certification boards to screen applicants and (4) gives colleges and universities a structured mechanism to assess, evaluate, and improve the quality of their programs. Recently ABET added a new criterion on Continuous Improvement, bringing the total criteria to nine.

Several of the criteria explicitly address the kinds of skills that are satisfied by interdisciplinary, team-based courses[5]. As mentioned previously, engineering students take the ILE course as an elective, which complements the required capstone design course for civil engineering students (CEE 290). Taking both design classes help civil engineering students exceed the minimum ABET criteria, contributing to the satisfaction of all parts of Criterion 3, a through k, except for parts b and i; specifically:

Engineering programs must demonstrate that their students attain the following outcomes:

a. an ability to apply knowledge of mathematics, science and engineering
c. an ability to design a system, component, or process to meet desired needs with realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability and sustainability
d. an ability to function on multidisciplinary teams
e. an ability to identify, formulate and solve engineering problems
f. an understanding of professional and ethical responsibility
g. an ability to communicate effectively
h. the broad education necessary to understand the impact of engineering solutions in a global economic, environmental, and social context
j. a knowledge of contemporary issues

k. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

Also, the ILE course contributes to the new Criterion 5 (Curriculum) which replaces Criterion 4 (Professional Component), and defined as the process of devising a system, component, or process to meet desired needs. ABET requires that design be integrated throughout the curriculum, culminating in a major or capstone design experience: Students must be prepared for engineering practice through a curriculum culminating in a major design experience based on the knowledge and skills acquired in earlier course work and incorporating engineering standards and multiple realistic constraints. Also, the civil engineering program criteria (new Criterion 9 in 2008) require ...that graduates *can…design a system, component*, or process in more than one civil engineering context.

B. Meeting and Exceeding the Minimum ABET Design Requirements

Because the requirement for multiple disciplines (Criterion 3d) ":… ability to function on multidisciplinary teams…" no longer applies only to the capstone design, the ILE course is more valuable for helping to satisfy this criterion for ILE students. Also the true interdisciplinary experience is stronger than the required multidisciplinary criterion, which can be satisfied by teams in two different civil engineering areas such as structural engineering and soil mechanics. ABET felt that an interdisciplinary teaming requirement would be difficult to include because it relied on cooperation with other department or programs and perhaps beyond the control of the accredited program, so they weakened this requirement a few years ago.

Furthermore, this ILE course exceeds the minimum ABET requirements of Criterion 3.c satisfying the intent of the original and more stringent EC 2000 statement that the capstone design course "…include most of the following considerations: economic; environmental; sustainability; manufacturability; ethical; health and safety; social; and political in the major culminating (capstone) design course." Engineering students are not just role playing to cover the various required non-engineering disciplines, but rather they are assigned to true interdisciplinary teams in their major area of expertise, working directly with students in non-engineering majors from a wide variety of majors.

V. Conclusion: A Living Lesson

The ILE course distinguishes itself from other project-based courses that students may have in their discipline in three separate areas; empowerment of the students, exposure and interaction with students from other majors, and the ability to engage students as potential alumni donors to the university.

Students have commented in the course evaluations they complete that the ILE experience gave them a distinct sense of empowerment, referring to the fact that they are given a project with no set guidelines but rather a request for a recommendation on how they can improve their campus environment. This sentiment is supported by recent

graduates who come back to campus or email their past advisors thanking them for the ILE opportunity. These former students claim that the ILE course truly helped to prepare them for their first job because they had experience being asked to produce a result without being given the exact process with how to achieve that result.

The new product development process (see Fig. 1) used by the Integrated Product Development (IPD) program, was applied by most of the studies.[7]

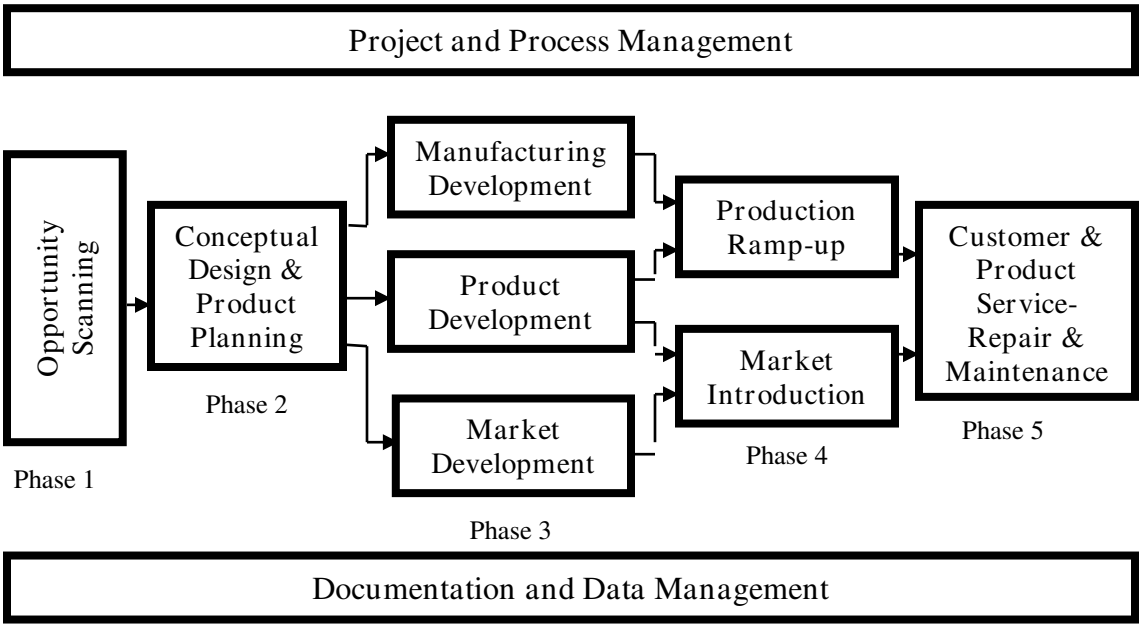

Figure 1. New Product Development Process as Modeled in Lehigh's IPD Program

Previous students have also told their advisors that they enjoyed the opportunity to work with students outside of their major. The students are given the opportunity to meet and interact with students outside their discipline, providing both a new working experience and allowing them to make new friends and connections. Before enrolling in ILE some students have spent the past 3 years in school taking classes with the same 30 students in their major. When they work on class projects with other students in their major, they have a predetermined role as a group leader or a role player which may have been established during their sophomore year. Entering a new group with students they may not know provides students the chance to take on a leadership role they may have not felt comfortable taking before.

Another valuable aspect of this project is that it allows students to come back to their alma mater and see a building or a facility that they helped design. Knowing that their project may be built motivates students to truly pour their efforts into these projects, and can help them envision the effect they can have on the university. The fact that these students have left a physical imprint on their college campus will also help to bring them back as alumni and stay involved in the school. Students participating in the ILE course

will be excellent resources for fundraising future ILE projects because they have personally seen the value in the course and the effort that is involved.

VI. Recommendations for Grading and Assessment

Grading of all students was conducted in a similar manner; only the civil engineering student grading is described here to give some insight into the process. Dr. Lennon (paper co-author) supervised all civil engineering students from 1998 to 2005 in all ILE sports projects including the golf projects, providing a consistency from year to year, and Dr. Weisman directed civil engineering students in 2006 and 2007. The supervising faculty applied their own grading system for the overall oral and written presentations and provided summary grades to the instructors. For example, Dr. Lennon adapted the civil engineering capstone design system for presentations: each individual speaker was evaluated for Content, including knowledge of the subject, clarity and response to questions, and Presentation where they were evaluated for preparation, effectiveness of visuals, professional style including eye contact. Immediately after the presentation, Dr. Lennon would share his evaluation of all students with the course instructors and provide any comments, sometimes negative, in his area of expertise. When warranted, he would have followed up discussions other faculty; it was common to discuss the performance of the architecture group with the architectural faculty supervisor to reach a consensus about the civil engineers' and architects' performance and each role in the group.

The instructors compile faculty and student evaluations, form their own recommendation, and consult with the individual faculty supervisors. Any differences in evaluations were discussed further, with the instructors often putting the evaluation of a particular supervisor's student in context with the other students.

One example of an unexpected grading experience is related here. Dr. Lennon was once retained as a consultant by an alumnus at an environmental & engineering consulting firm, hired by a golf design firm to determine if sufficient water resources existed to maintain irrigation at a proposed 18-hole golf course in Pennsylvania. He also interacted with extension service employees for design construction and maintenance of ponds, and got their permission for students to contact them. When the students ignored repeated suggestions to consult the pond designer when they struggled with the pond design, and then submitted a poor pond design in the final report, Dr. Lennon lowered their grade and met with them to be sure they understood that their poor decisions not to make use of an excellent resource impacted their grade in this course, but out in the real world it could result in a poorly implemented design and/or loss of prestige for their firm. Dr. Lennon tried to make it a learning experience so the students would not repeat such the oversight of ignoring available resources.

Throughout the course the instructors and faculty supervisors interacted with the students and were usually aware of any problems with their peers' contribution or performance from these informal avenues. A more formal peer evaluation was conducted at the end of the course, where each student was asked to evaluate what share of a hypothetical

financial bonus each student deserved. In 2005, each student had 75 points to distribute among the 14 members, resulting in an average evaluation of about 5.4 points per person. Each of the 14 responses was entered into a matrix so that each student received an evaluation. Individual assessments of each other ranged from low of 0 to the high of 10 points allowed; the lowest total evaluation was 52 (3.7 average) and the highest was 113 (8.1 average). Students are asked to give an explanation for each score they give. Sometimes a student may give a low score with the explanation that they were not in any sub-groups with the person and therefore did not see them complete much work, this allows the advisors to properly weight their evaluation. Generally, the peer evaluations were consistent with the faculty evaluations, and if not, they were discussed at length by the faculty. For example, one of the four civil engineering students one year was quietly competent and made a good contribution, but did not convey accomplishments or effort to the team and got a low peer score. The instructors took this into consideration when assigning a final grade to recognize the contribution, but used it as a learning experience to let the student know that being a more forceful would be in the student's best interest.

As described above, the faculty and peer evaluation system has worked extremely well in the ILE sports complex courses over the last decade. However, the authors investigated and recommend that a more formal assessment be performed using a procedure to help provide consistence. The model assessment and evaluation proposed is based on Lehigh's Integrated Product Development (IPD) program, which includes a comprehensive set of rubrics for consistent evaluation of each oral presentation as shown in Table 3.[6] The authors have obtained analogous rubrics for the written presentations based on the IPD model.

In the future, Bloom's Taxonomy will be used to redefine the Course Objectives in terms of Bloom's cognitive six development levels, which are knowledge, comprehension, application, analysis, synthesis, and evaluation.[9]

Table 3: Sample rubric used in Integrated Product Development (IPD)[6] Program to assess final presentation; analogous rubric to be used for final report and other course components

Professionalism	Overall Content	Technical Content	Preparedness	
Presentation was given in such a manner that the students could have been mistaken for employees of the company.	Every topic covered was well researched and relevant. Audiovisual components contributed a great deal to the presentation.	Introduction of company, project objectives, market research, design concepts, technical & financial feasibility & plans for future work were all fully discussed within the time constraints.	Every aspect of the presentation was well rehearsed and every member of the team was prepared to speak and answer questions about their topic area.	exemplary
9 9.5 10	9 9.5 10	9 9.5 10	9 9.5 10	
Presentation was well done and appropriate. It had a flavor of professionalism that was slightly beyond the student's academic status.	The topics covered were presented with a fair amount of detail and level of relevance. Audiovisual components supported but did not enhance presentation.	Introduction of company, project objectives, market research, design concepts, technical & financial feasibility & plans for future work were addressed with some detail mostly within the time constraints.	Most of the presentation was prepared and most team members were able to speak about their topic area. Most questions were answered.	good
8 8.5 8.9	8 8.5 8.9	8 8.5 8.9	8 8.5 8.9	
Presentation was given in a manner consistent with student behavior. No level of professionalism was attained.	The topics covered were limited in scope and depth. Audiovisual components were problematic and detracted somewhat from the presentation.	Introduction of company, project objectives, market research, design concepts, technical & financial feasibility & plans for future work were not all addressed & time was not used wisely.	Some of the presentation seemed prepared. One or two team members dominated; some members were less prepared than the rest. Some ability to answer questions was apparent.	limited
7 7.5 7.9	7 7.5 7.9	7 7.5 7.9	7 7.5 7.9	
Presentation was not only unprofessional but below college level standards.	The topics covered were not clearly related to the project outcome nor were enough topics covered. Audiovisual components were either scarce or inappropriate.	There didn't seem to be a full understanding of the need for above topics to be included in presentation. Only a cursory view of the project was presented.	The team was not at all prepared to speak or answer questions on the topics relevant to the project. No rehearsal was apparent.	deficient
6 6.5 6.9	6 6.5 6.9	6 6.5 6.9	6 6.5 6.9	
Raw Scores: Professionalism Score	Overall Content Score:	Technical Content Score:	Preparedness Score:	
Formula: _____ x 1 = _____	_____ x 2 = _____	_____ x 2 = _____	_____ x 1 = _____	Add across Total:_____

References

1. Lengieza, K. M., Caffrey, J. M., Norelli, D., Lennon, G. P., Ochs, J. B., Munley, V. and Sterrett, J. "Student Design of Lehigh University Golf Facilities," American Society of Engineering Educators, 2007 Conference, Honolulu, Hawaii, 2007.
2. Albro, Rob, Jim Angelotropolous, Rachel DeLoach, Nick DiCello, Jason Faberman, Nate Gardener, Mike Infanti, Greg Jorgensen, Stephanie Laski, Danielle Lavoie, Holly Shoup, Audrey Tantamjarik, Kate Wroblewski, Carl Moses, and Vincent Munley, "Land Use Analysis For a Parcel of Lehigh University Property: A Joint Environmental-Economic Impact Study" Final Report, 1998 Lehigh Earth Observatory.
3. Anderson, Karilyn, Zachary Baron, Danielle Brock, Kevin Deger, Kevin Frost, Robert Hampson, Kevin Harmann, Jeff King, Daniel Norelli, Joe Raniszewski, Eric Rimsky, Adrienne Roth, Jennifer Vigdor, Jason Zimpfer, Vincent Munley, and Joe Sterrett, "Lehigh University Golf Course Operation and Maintenance Analysis" Final Report, 2005 ILE Class.
4. Antes, Vincent, Elizabeth Callahan, Michael Collins, Michaela Cooney, Kyle Dunleavy, Brittany Hamilton, Eugene Johnston, John Piascik, Emily Roth, Logan Strenchock, Brannan Thomas, Jeffrey Wieand, Vincent Munley, Joseph Sterrett, and Rick Weisman, "ILE Fall 2007: A continuation of the master planning of Goodman Campus." Final Report, 2007 ILE Class.
5. Accreditation Board for Engineering and Technology (ABET), Inc. www.abet.org.
6. Getzler-Linn, Lisa, John B Ochs, and Todd A. Watkins. "Program and Student Performance Assessment in Team-Based Project Courses with Focus on Technical Entrepreneurship and Product Development: Lehigh University's IPD Program." Proceeding from the January 2006 USASBE Conference, Tucson AZ, January 2006.
7. Ochs, John B., Gerard P. Lennon, Todd A. Watkins, and Graham Mitchell. "A Comprehensive Model for Integrating Entrepreneurship Education and Capstone Projects while Exceeding ABET Requirements," Proceedings of the annual meeting of American Society of Engineering Educators, 2006.
8. ASCE Magazine Editorial Staff, "Students Design Stadium for Lehigh University." American Society of Civil Engineering Magazine February, 1999, p.24
9. Bloom, Benjamin S., "Taxonomy of Educational Objectives: Cognitive Domain," New York, David McKay and Co. 1956.

Appendix A: Example Progress Report from 2007

Progress Report

Integrated Learning Experience – Athletic Design Project
October 12th, 2007

Overview Group -

Accomplished this week:

- Generated guest list for mid-term presentation
- Worked on outlining the mid-term presentation and set goals for each individual group

Deliverables for next week:

- Send invitation to guests for midterm presentation
- Create and compile PowerPoint presentation for mid-term

SPECS/Rules and Regulations -

Accomplished this week:

- Continue to provide support to groups that may need zoning code information

Deliverables for next week:

- Reach out to individual project groups to determine information that may be valuable to their deliverables

Funding –

Accomplished this week:

- Met with Chris Marshall prior to this meeting and will update entire group as necessary

Deliverables for next week:

- Research the set-up of the class gift, i.e. how much money is available, when will it become available, how can we monitor the percentage of the class that has given so that we can project the attainability of the gift
- Develop and submit for approval a survey to determine the interest level of the senior class donating to the senior gift

GIS Survey –

Accomplished this week:

- Met with Professor Hargreaves last Friday to demonstrate ArchGIS, set up a weekly meeting on Friday's at 1pm
- Set up meeting for Friday, October 5, 2007 with representatives from the Athletic Department and Environmental Sciences Department to determine the need and requirements of maintaining a GIS database of Goodman Campus

Deliverables for next week:

- Continue to explore GIS capabilities and begin work in areas that are defined in Friday's meeting

Appendix A continued:

Traffic/Parking/Signs –

Semester Goals:

-Improve parking by the Field House. Find most cost effective solution that is still aesthetically pleasing and convenient.
-Look into the feasibility of converting the corn fields north of the football fields into paved parking
-Examine traffic flow from the south if one were to come from Philadelphia.
-Examine different possible scenarios and determine for these scenarios or events that we have sufficient parking.
-Look into making a loop-around for trolleys arriving in front of the south end of the football stadium, and possible parking there.

Accomplished this week:

- Met with Joe Sterrett on Wednesday to determine the group's focus for the semester

Deliverables for next week:

- Revise semester schedule to achieve deliverables

Entrance Design –

Semester Goals:

- Site Plan of location of entrance including elevations and details
- Rendering of proposed entrance
- Cost estimates including quantities

Accomplished this week:

- Meeting with Tony Corallo at 12pm today
- Discussed location possibilities for the entrance
- Visited local colleges to look at their entrances (pictures uploaded to Blackboard)

Deliverables for next week:

- Work on generating actual diagrams and pictures of proposed design for the mid-term presentation

Northeast Corner Development -

Accomplished this week:

- Discussed need for specific ideas and costs to present at the mid-term presentation
- Working on a survey that could be used to gage student and staff interest in possible ideas

Deliverables for next week:

- Brainstorm ideas for the area based on other colleges and student input
- Begin to evaluate benefits/drawbacks of all ideas proposed