AC 2009-1735: ASSESSING TEAM WORK AND ETHICAL AWARENESS IN INTERPROFESSIONAL UNDERGRADUATE TEAMS AND ENTREPRENEURIAL STUDENT START-UPS: REPORT #1

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Mary Raber, Michigan Technology University

Mary Raber currently serves as Associate Director for the Institute for Interdisciplinary Studies and Director of the Enterprise Program at Michigan Technological University. This program focuses on undergraduate technical and professional skill development by providing a multidisciplinary team environment in which students address real-world projects for industry, community and government organizations. Ms. Raber has overseen the implementation and growth of the Enterprise Program at Michigan Tech since its inception in 2000, and is responsible for its overall coordination and development. Her responsibilities include corporate sponsorship development, interdisciplinary program evaluation and assessment, and workshop/course instruction in the areas of teaming and leadership. She received her BS in Mechanical Engineering from the University of Michigan and an MBA from Wayne State University. Before joining MTU she held various engineering and management positions during a 15 year career in the automotive industry.
Introduction

A four-university collaboration has received National Science Foundation (NSF) Course, Curriculum and Laboratory Improvement (CCLI) funding for a three-year project with two primary goals: 1) to develop a database of reliable and valid measures for assessing attainment of teamwork skills and ethical awareness in undergraduate students enrolled in multidisciplinary project based, design projects, and 2) to identify and describe ‘best practices’ from across these institutions that improve the achievement of learning objectives and thereby increase program quality. Example learning objectives from one course are described as follows: “Students enrolled in these project courses will experience and demonstrate an understanding of ‘best practices’ in the following five areas: 1) The “idea to implementation” process, 2) written, oral and graphical communications, 3) teamwork, and leadership, 4) professional and ethical behavior, 5) the entrepreneurial mindset.” Each of the partner schools has similar learning objectives and collectively, we have agreed to focus on two: 1) teamwork and, 2) ethical awareness.

The partner universities are the Illinois Institute of Technology, Lehigh University, Michigan Technological University, and Purdue University. This collaborative effort started September 1, 2008 and runs through August 31, 2011. All four universities engaged in this project have developed nationally and internationally recognized experiential learning courses that engage undergraduate students in real-world projects that due to projects’ size and scope, require a multidisciplinary team. These common characteristics provide a diverse test bed to investigate and validate new pedagogies in STEM education.

An acknowledged driving force in this effort is the requirements for accreditation as prescribed by the Accreditation Board for Engineering and Technology (ABET), in particular Criterion III and IV. Based on recent success with the accreditation process, the four partnering schools are encouraged to continue this development.

This is the first of several progress reports that the collaborators will present in the hope of demonstrating progress, disseminating results and soliciting feedback from Science, Technology, Engineering and Mathematics (STEM) educators. This report describes our project goals, the experiential learning environments, the assessment of experiential learning, the overall project plan, our progress to date and the next steps.

Project Goals

Two primary project goals are to develop measurement tools to 1) assess teamwork and ethics awareness and 2) best practices in experiential, multidisciplinary team projects. These can be broken down as follows:

1a) to develop reliable and valid measures for assessing teamwork,
1b) to develop reliable and valid measures for assessing ethical awareness,
2a) to identify and describe best practices to achieve the learning objectives in these courses,
2b) to apply and continuously improve these best practices at all four institutions to ensure quality.
An implicit starting point for this project is agreement on common learning objectives. The explicit end point is the development of a database or other mechanisms to share the results of our collective efforts among the partners as well as other STEM educators.

Experiential Learning Environments

Common to all four partnering universities is the experiential learning environments where multidisciplinary teams of undergraduates work on real world projects. While each school is unique in size and approach, they have much in common including a willingness to share.

**IIT’s IPro Program:** The Illinois Institute of Technology (IIT) is a private urban Chicago university with 2,300 undergraduates and 4,500 graduate students with 18 percent minorities and 34 percent foreign. IIT’s Interprofessional Projects [IPRO] program annually supports over 50 multidisciplinary teams from 4 to 10 junior or seniors from over 30 majors working on design projects covering service learning, entrepreneurship, process improvement, new product and new venture development.

**Lehigh’s IPD Program:** Lehigh University is a small private university in Bethlehem, PA with 4,600 undergraduates and 2,000 graduates. In Lehigh’s Integrated Product Development (IPD) program each calendar year 170+ students from engineering, business and design arts work in 25+ teams on new product development and process improvement projects provided by sponsoring companies that are categorized as established, local start up or student start-up.

**Purdue’s EPICS Program:** Purdue University is a large public university located in rural West Lafayette, IN. Purdue’s Engineering Projects in Community Service (EPICS) is the nation’s best-developed and best known program in service learning. Students at any level in any major can enroll in EPICS courses where they partner with local non-profit organizations to bring technical solutions to social, environmental and community problems.

**Michigan Tech’s Enterprise Program:** Michigan Technological University, located in rural Houghton, MI is a small public university with 6,500 undergraduate students with more then 50 percent enrolled in engineering. Michigan Tech’s Enterprise Program offers the opportunity for students to participate in multiple level, multi semester, team based projects where the teams “… operate like a company to solve real world problems…”

Assessment of Experiential Learning

The IIT IPRO partners have researched recent published literature and they have developed the pedagogical and genitive learning foundation for the design and development of experiential learning environments and related topics. For the purposes of this paper, the conclusion of that research can be summed as the following:

1) Assessing of learning within an experiential learning environment is challenging,
2) Systematic research of the benefits of experiential learning is scant,
3) Models do exist for how students learn in solving unstructured problems,
The “Steps for Better Thinking” by Wolcott and Lynch\textsuperscript{11,12} and “reflective judgment model’ by King and Kitchener\textsuperscript{9,10} and advanced by others seem appropriate instruments for assessing experiential learning.

Based on the research done to date, our collective and individual assessment of learning by students engaged in multidisciplinary team based projects at all four institutions will involve the following:

1) The development of explicit criteria for success
2) On going, in-process assessment at gradable moments during the process (versus at the beginning and end)
3) Assessment of prior knowledge and the development of effective in-process feedback mechanisms
4) Transfer of learning with follow-on opportunities to practice what has been learned in order to reinforce motivation and self confidence to identify and manage risks in support of innovative solutions

Project Plan

As proposed in our NSF CCLI grant\textsuperscript{10}, we will “…develop a continuous multilevel assessment process that will measure (student’s) achievement of ‘soft skills’ knowledge and application of this knowledge in a multidisciplinary team environment…” while working on real-world projects in the context of our individual academic programs under an umbrella of common educational objectives.

Quoting from our proposal, “During the first year of the grant we will all become familiar with the multidisciplinary team project programs at each the four schools involved in this project and implement some assessment tools and innovations on a pilot basis. We will also meet with our partners several times to learn more about how their programs work, under what constraints they operate, how they have defined their learning objectives, what assessment measures are currently used, etc. We will further work with our partner schools to evaluate the congruence of our learning objectives, determine which learning objectives will be assessed at more than one school, set up joint assessment measurement processes (sampling, instruments, data collection, analysis) and decide on the interventions to test. Finally, sample teams from each of the partner schools will participate in the IIT IPRO Days. All partner schools will share data derived from our common assessment tools, intervention programs and program management practices.

During the second and third years of the grant we will focus on gathering and analyzing assessment data to determine which interventions significantly improve project team performance and student attainment of learning objectives and implement or improve those interventions in partner schools. We will also be disseminating results to the larger audience of peer institutions through joint presentations and publications with our partner
schools and seeking additional funding to expand the network of schools in the research program.”

Measures and Assessment Process

Collectively our assessment process focuses on the participating students demonstrating competences in four of the ABET ‘meta-learning objectives’ namely: 1) working in multidisciplinary teams, 2) oral and written communications, 3) project management, and 4) professional and ethical behavior. At each location multidisciplinary student teams will be working on real-world projects following an “idea to implementation” process while hopefully developing an ‘entrepreneurial mind set.’ Our proposed area of concentration for the NSF CCLI grant will be assessing teamwork and ethical awareness. Our assessment process will include:

1. Assessing cognitive-declarative knowledge about our learning objectives,
2. Self assessment of the learning objectives,
3. Judge evaluations of mastery of learning objectives,
4. Student course assessments.

Other instruments including rubrics developed to assess gradable moments throughout the idea-to-implementation process will be shared and vetted. Also of interest to the group are piloting interventions including:

1. Enhancing teamwork
2. Developing project management skills
3. Cognitive-declarative knowledge of applications through written and oral presentations
4. Developing reflective judgment thinking
5. Developing faculty expertise as guides and mentors

Current Status and Next Steps

To date the collaborators have established and web site at IIT’s IGroups to be a repository for assessment tools including some twenty rubrics developed to assess gradable moments in the idea-to-implementation process. A self assessment questionnaire has been developed for assessing ethical awareness that includes several ethics vignettes that a typical undergraduate might encounter within the context of a multidisciplinary project course and its deliverables. This is posted in Appendix A. This self assessment is completed at the beginning and at end of the project course. Analysis of this data will be completed before the June 2009 ASEE conference and will be presented there.

In the spring 2009 semester, the task is to develop an integrated approach to 1) “idea-to-implementation process, 2) teamwork and 3) ethics. A framework has been constructed where teams are being evaluated on the tasks to be performed\textsuperscript{11}, the tasks to be performed follow and repetitive feedback loop process that emphasizes reflection at key stages\textsuperscript{12} and the teamwork is to be done within a broad ethical framework\textsuperscript{13,14}.

For example Lehigh University’s Integrated Product Development (IPD) program follows the five step process shown below in Figure 1. The faculty and staff work with industry sponsors on step #1, Opportunity Scanning, to identify projects during the semester before the January start of the year long project. Students teams of approximately six students from engineering, business
and design arts work on step 2, Concept Design and Product Planning and step 3, the parallel and integrated development of the product, its manufacturing system that produces it and the marketing plan. In general the sponsoring companies are responsible for the resource-intensive steps 4 and 5 of product and market launch and service and support.

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

Sponsoring companies include national and international corporations, regional small companies, local entrepreneurial start-ups and student entrepreneurial start ups. In the IPD courses Step 2 and Step 3 are combined into the process shown in Figure 2. This process is taken from the text for the course “Product Design and Development” by Ulrich and Eppinger (REF). The multi step iterative process shown in Figure 2 starts with the problem definition which is converted to an opportunity statement and a mission statement. Our twelve years of experience with this process have shown that with some variations, it is equally valid for manufacturing process improvement projects as well as new product development projects.

Figure 2. Process followed in the Lehigh’s IPD courses (Modified with permission from “Product Design and Development” by Ulrich and Eppinger12)
Lehigh University’s IPD program runs for two semesters over the calendar year and the process in Figure 2 is divided into the following six milestones each with a tack board session where the team must defend the work competed.

During the spring semester (January to May) the teams 1) develop an understanding of the business and technical context of the project, 2) develop innovative solutions and 3) test and evaluating the concept. In the fall semester (August to December) the teams 4) fabricate a prototype, 5) test the prototype and 6) reevaluate the solution and impact. Other deliverables include weekly progress report to the sponsor, written and oral final reports, personal notebooks and poster each semester. Each of these gradable moments is supported by lecture material, examples from previous teams and rubrics used for grading. An example rubric for the first Tack Board in the spring semester is shown in Appendix B.

Conclusion

We are at the starting point of this three year project and together we hope to develop, use and then make available to all STEM educators, a tool set of assessment instruments that we hope will be useful to anyone doing multidisciplinary team-based, experiential projects as part of their engineering education.

References

1. Lehigh University’s Integrated Product Development (IPD) web site:
   http://www.lehigh.edu/ipd/
3. Illinois Institute of Technology Interprofessional Projects (IPRO) web site: http://ipro.iit.edu/home/main.php
4. Purdue University’s Engineering Projects in Community Service (EPICS) web site: http://epics.ecn.purdue.edu/
5. Michigan Tech’s Enterprise Program web site: http://www.enterprise.mtu.edu/


Appendix A. Self Assessment for Ethical Awareness

Instructions:
The IPD program would like to measure how students feel about their confidence in recognizing and dealing with ethical issues. Your individual responses will not be reported to the course leader. Your responses will be used for group analysis, and to guide our future activities in developing greater awareness of ethical issues.

To complete the questionnaire please read the following questions carefully. Rate each statement by circling the number that best represents the degree to which you agree with the statement. Circle only one of the response options.

Part I: How confident am I about recognizing and dealing with ethical issues?

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly Agree</th>
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<tbody>
<tr>
<td>1. When making a decision about an ethical issue, I do not need to consider anything except my own sense of what is “right” and what is “wrong.”</td>
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<td>2. I can identify when a decision or problem has an ethical component.</td>
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<td>3. I can confidently defend the decisions I make about ethical issues.</td>
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<td>4. Ethical decisions are sometimes focused on deciding between the best of many good solutions, not just “good” vs “evil.”</td>
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<td>5. After adolescence, there is not much point to trying to teach someone about ethics.</td>
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<td>6. In some jobs, there really are no ethical issues.</td>
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7. When faced with an ethical issue, most people will agree on what the most appropriate course of action is.  

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<th>Strongly Disagree</th>
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<th>Agree</th>
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8. I should be held accountable for knowing and following the Code of Ethics for my profession.  

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<th>Strongly Disagree</th>
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<th>Agree</th>
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9. My work should contribute to the betterment of society.  

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<th>Strongly Disagree</th>
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10. Learning about ethics is an important part of my development as a professional.  

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<th>Strongly Disagree</th>
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Part II: Examples – When is it an “ethical issue”?

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1. In designing a break pad for a new car, the decision to reduce the pads thickness and therefore reducing its operating life in order to reduce cost to compete with foreign competition, is an ethical issue.  

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<th>Strongly Disagree</th>
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2. When considering tradeoffs and decisions between alternative design solutions, including environmental impact as a primary criterion, is an ethical issue.  

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3. Removing all OSHA mandated safety features for an industrial product made in the USA and sold to Asia Pacific countries in order to compete with other competitive devices, is an ethical issue.  

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4. Downloading copyright protected software, songs or videos without paying for them, is an ethical issue.

5. Including a team member’s CAD drawing in your own notebook without giving that person credit for their work, is an ethical issue.

6. Showing up late for a team meeting without explanation or apology, is an ethical issue.

7. Stating in a report or at a meeting that you “contacted your sponsor” when you e-mailed him/her, is an ethical issue.

8. Exaggerating your reported time spent completing a task, is an ethical issue.

9. Photo-copying a section of a copyrighted book for your personal use, is an ethical issue.

10. Claiming you are part of the team that invented a new product and therefore must be listed as an co-inventor on the patent application, is an ethical issue.

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Part III: DEMOGRAPHIC INFORMATION

Instructions:
The following questions are not meant to identify any individual participant. They have been created for analysis of learning objectives based on overall demographics, not on individuals. Demographic information will only be used for group analysis and will not be used to identify you or your teammates.

To complete this section, fill in the information requested or please place an ‘X’ next to the appropriate response.

1. Age:_______

2. Gender:
   a. Male _______
   b. Female _______
3. Year in school:
   a. Freshman _______b. Sophomore _______c. Junior _______d. Senior _______
   e. Fifth year_______ f. Graduate ______
4. What is your country of citizenship?_______________________
5. GPA: ______
6. Academic major/majors and minor:_____________________________
7. How many semesters have you taken IPD? _________
8. What is/was your IPD project title? _____________________________
9. Who is/was your faculty adviser? _____________________________
10. Who is/was your peer mentor? ________________________________
## Appendix B. Example Rubric for grading a team member’s personal notebook

<table>
<thead>
<tr>
<th>IPD Process Content</th>
<th>Record of Intellectual Property</th>
<th>Format</th>
<th>Essential Elements</th>
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<tbody>
<tr>
<td><strong>Project Journal:</strong></td>
<td>Daily written evidence of all IPD topics from text, lecture and videos that is a clear chronological record. Consideration is given to BOTH project development and team leadership/team member behavior. Extensive daily written evidence of reflections of the IPD course objectives as learned by the writer based on experiences learned during the execution of the project.</td>
<td>Clear written evidence of all ideas, both carried out and abandoned. All analytical work, design ideas, technical specifications, experiments, financial estimates, sources and significant thinking are noted and dated in this record.</td>
<td>The notebook itself is the correct one. The requisite care was taken to reserve pages for a Table of Contents, each page was numbered, signed and dated. Authorship is clearly identified. Entries were not crowded and ink was used when any patenting questions were involved and all data was entered contemporaneously. There is a clear and concise link to the weekly team progress reports including time spent.</td>
</tr>
<tr>
<td><strong>Project Diary:</strong></td>
<td>Weekly written evidence of some IPD topics from the text, lecture and videos that is a clear chronological record. Consideration is given to BOTH project development and team leadership/team member behavior. Some written evidence of reflections of the IPD course objectives as learned by the writer based on experiences learned during the execution of the project.</td>
<td>Clear written evidence of some ideas both planned and carried out - few of the abandoned plans are mentioned. A good deal of analytical work, design and technical specifications and sources are recorded in the notebook.</td>
<td>The notebook is the correct one and a Table of Contents was added or squeezed in. Most pages are numbered signed and dated. Little preference was given to ink vs. pencil regardless of the information being entered. Data seemed to have been entered in a regular and contemporaneous basis. Authorship is generally clear. There is some relationship between the notebook and the weekly team reports.</td>
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<tr>
<td><strong>Project Scrapbook:</strong></td>
<td>Some evidence of some IPD topics from the text, lecture notes and video that are organized as collection of notes, sketches, etc. with isolated written thoughts and reflections that provide evidence of some sense of direction, progress and lessons learned.</td>
<td>A few plans for the project, along with a scattering of design ideas and technical references are in evidence. There is some reference to sources and ideas for the project.</td>
<td>Experimental/business/market data, interview data, analyses &amp; interpretation thereof; Analytical work, calculations &amp; conclusions; Graphs, charts with labels, titles and interpretations; Sketches, CAD drawings, models &amp; photographs titled and interpreted; References to information sources; Test instrumentation output (if applicable) with titles and interpretation.</td>
</tr>
<tr>
<td><strong>Project Notepad:</strong></td>
<td>A collection of lists, class notes, facts &amp; figures, etc. that are meaningful mainly to the writer of the Notebook. A limited and scattered message to the outside reader.</td>
<td>Minimal project ideas or plans are recorded. Most of the written evidence is referencing class notes, team meeting notes or advisor's suggestions.</td>
<td>The notebook may be the correct one but no Table of Contents exists and for the most part the pages are either not numbered, not dated or not signed. Data has been entered haphazardly and at uneven intervals. Authorship and the link to the weekly team reports is unclear.</td>
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<th>Raw Score</th>
<th>Notebook Attributes Score</th>
<th>Record of Intellectual Property Score</th>
<th>Format Score</th>
<th>Essential Elements Score</th>
<th>Total</th>
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Exemplary: 8.6 - 9.3
Proficient: 7.5 - 8.5
Limited: 6.6 - 7.5
Deficient: 5.6 - 6.5
Subtotal: divide by 10