AC 2011-2562: INTERACTIVE DESIGN AND TECHNOLOGY RESEARCH:

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Interactive Design and Technology Research: 
From Ideation to Implementation

Abstract

The growth and acceptance of interdisciplinary education has blurred the boundaries associated with more traditional and insular curricular models. In this environment, multidisciplinary projects are fast becoming the norm. The purpose of this paper is to introduce the framework and working process of a new interdisciplinary capstone course that creates a dynamic new learning context by combining an *Industrial Design Studio* with a *Computer Engineering Technology Laboratory*. Integrating two core courses, senior students in Industrial Design and Computer Engineering Technology are given the opportunity to participate in a high quality educational environment with authentic and tangible learning experiences.

The paper discusses the collaborative course design embedded in a combined studio/laboratory setting. This instructional approach will provide a unique educational experience that allows students to: (1) learn knowledge and tools in two disciplines that can be used applied toward the completion of a real-world, collaborative, and interdisciplinary research project; (2) develop complementary skill sets across two disciplines which will allow students to design and build a working prototype; (3) use critical thinking to analyze the effectiveness and quality of the research process and its outcomes.

Unlike traditional learning in industrial design and engineering technology programs with an emphasis on *design concept prototyping* and *technological prototyping* respectively, this interdisciplinary course integrates these parallel tracks to provide a seamless collaborative learning experience. From the identification of a research problem to the development of a working prototype, the collaborative studio/laboratory reinforces creative and critical thinking with an emphasis on human, technological, and aesthetic aspects of product development. This approach to undergraduate education can provide constructive and authentic learning experiences to meet the industry needs. This paper reports the preliminary results of the pilot phase of a one-year grant awarded through the Office of Undergraduate Discovery Programs at the University of Houston.

Introduction

Interdisciplinary approaches to enhance an undergraduate research have become an important component for many tier-one research universities. Very recently, the NSF-TUES Transforming Undergraduate Education in Science, Technology, Engineering and Mathematics (TUES), formerly known as NSF-CCLI (Replaces Course, Curriculum, and Laboratory Improvement (CCLI)), had shifted its focus to include a few new guidelines for proposals including:

- Proposing approaches that enhance student learning and can be adapted easily by other sites

Page 22.938.2
Creating Learning Materials and Strategies:
- Guided by research on teaching and learning
- Incorporate and be inspired by advances within the discipline
- Implementing New Instructional Strategies
- Contribute to understanding on how existing strategies
  - Can be widely adopted
  - Are transferred to diverse settings
  - Impact student learning in diverse settings
- Developing Faculty Expertise:
  - Enable faculty to acquire new knowledge and skills in order to revise their curricula and teaching practices
  - Involve a diverse group of faculty

Assessing and Evaluating Student Achievement:
- Develop and disseminate valid and reliable tests of STEM knowledge
- Collect, synthesize, and interpret information about student understanding, reasoning, practical skills, interests, attitudes or other valued outcomes
- Conducting Research on Undergraduate STEM Education:
  - Explore how
    - Effective teaching strategies and curricula enhance learning and attitudes,
    - Widespread practices have diffused through the community Faculty and programs implement changes in their curriculum.

Following the guidelines provided by Quality Enhancement Plan (QEP) and the NSF-TUES, the authors met during the summer 2010 to plan and execute a new plan to measure and assess student learning outcomes in fall 2010 between two senior level courses in two dissimilar disciplines: Computer Engineering Technology (CETE) in the College of Technology and Industrial Design (ID) in the College of Architecture. The following section describes how the authors formulated the collaborative research between the two programs by describing the Student Learning Outcomes.

Student Learning Outcomes

The following QEP Student Learning Outcomes are addressed for each of the six criteria devised for the two disciplines.

1. Students will be able to formulate a research question or problem.

   **CETE:** All senior project students in the Computer Engineering Technology program are required to take a sequence of two courses for their senior project. The first course is the proposal phase where students are required to do research using library resources, patent sites, the Internet, prior projects, course server, and
various other resources they find in order to identify an innovative idea that passes through the approval process for the course. Students are required to identify their research problem in one or more of the following areas:

- Bio-Medical Technology
- Security Technology
- DoD Technology
- Technology for Mobile Robots
- Space Technology
- Technology Impacting Societies
- Technology for Developing/Underdeveloped Countries
- Technology to Assist Elders
- Technology to Assist People Who Are Physically Disadvantaged
- Technology for Alternate Energy
- Forensic Technology

Students write weekly progress reports on their findings. Generally, students present several research problems and discuss them with the senior project team. This process helps students formulate their final research problem and present it to the class as a pre-proposal and a report halfway through the semester. The pre-proposals are reviewed and evaluated. Students continue to do in-depth research using technology tools on their chosen research problem. A successful final proposal presentation and report completes the proposal phase. In the implementation phase, students work towards development of a working prototype.

**ID:** A sequence of industrial design studios is selected and reconstructed to match with a sequence of two courses in CETE. Students in both disciplines are grouped from the beginning of research phase, and explore research problems collaboratively. Students will investigate diverse issues in 12 study areas based on their market, technology, and user research. Weekly journals are required for the ID students and individual study, respectively.

2. **Students will be able to identify basic principles and knowledge related to their research question or problem.**

**CETE:** The senior project class demonstrates the culmination of student knowledge and how they are able to apply it to their research problem. Often, students start with what they already know and independently or in team environment research and learn additional knowledge needed to formulate a research problem.

**ID:** Students understand how to apply appropriate design methods (literature review, observation, interview, etc.) to identify design problems and present research questions in research proposal. Design problems identify target user group, technology, market, and other service components. Data collection and analysis is systematically investigated and presented in mid-term presentation and research proposal. In addition to research questions, design opportunities are critically discussed and formulated in mid-term presentation. Research questions
and design problem statement guide the design development process and drive the evaluation of final design outcome.

3. **Students will be able to develop a research plan to address or resolve a specific question or problem.**

**CETE:** Senior project students are introduced to the project management via a workshop. They are also introduced to the intellectual property in general, and the process of filing patents at the University of Houston. Their research plan is well documented through the Microsoft Project program and shows schedule of deliverables and task assignments. Weekly progress reports reflect the progress made. Cost estimation, overall plan to implement the research problem is an important component of the overall evaluation of each team and members of that team.

**ID:** Students possess leadership and stewardship to plan and conduct appropriate research methods to address research questions. Diverse methods to cultivate teamwork (Gantt charts, digital file sharing, and virtual whiteboards) are applied to the design process and summarized in group presentations and final reports.

4. **Students will be able to collect and interpret data and information in an attempt to resolve the question or problem.**

**CETE:** Depending on the selected research problem, senior project students embark on data collection and interpretation of the data related to their research problems in order to justify the nature of their research. For example, data may be collected for the number of deaths due to health problems while driving a car. In order to reduce the number of deaths, students can develop a wireless emergency response system that monitors the health of a driver and reports the vital signs to a desired medical center in real time. Such vehicles are equipped with Global Positioning System (GPS) so that when an incident occurs, nearby emergency units can be dispatched to the right location immediately.

**ID:** Students collect qualitative and quantitative data with diverse research methods (literature review, questionnaire, survey, interview, video ethnographic study, and user observation). The analysis of data is carefully conducted in order to identify users’ latent needs in interaction and system usage. Mid-term presentations and final reports include visual mapping, SWOT analysis, and other graphic information to inspire holistic understanding of research problems. Students synthesize data and present important research findings creatively and critically. The process of data collection, analysis, and synthesis is carefully reviewed and documented qualitatively and quantitatively.

Design solutions should include the following:

- Design Form: function, materials, manufacturing process, parts, color
- Design Usability: interface design, human factors, universal design consideration
5. Students will demonstrate awareness of the responsible conduct of research.

**CETE:** Through reading professional organizations code of conduct, students become familiar with what it takes to be a professional. Students are required to read code of professional conduct of IEEE, ABET, and ACM.

Several cases are discussed in class related to the responsible conduct of research. Students are introduced to the *Rules of Professional Responsibility* used in most state laws. Four major sections elaborated on in the class are:

1. Responsibility to the Public
2. Competency for Assignments
3. Conflict of Interest
4. Improper Conduct

**ID:** Students explore creative design concepts and develop a useful, usable, and desirable design solution. The overall design process should focus on human-centered design and the enhancement of quality of life. The final working prototype is used to evaluate new product/system through the usability test of its effectiveness, reliability, and validity. Creative design thinking and critical thinking is embedded in the process of research and carefully documented in the final presentation and report.

6. Students will be able to articulate their research findings through written, performance, and/or oral presentations.

**CETE:** Senior project students have several milestones during a two-semester sequence. The written, performance, and oral presentations aspects of the course include:

1. Weekly progress reports for the proposal phase and biweekly progress reports for the implementation phase
2. Weekly discussions with the teams regarding their performance and review of their progress reports
3. Pre-proposal presentations, reports and several evaluations
4. Final proposal presentations, reports and several evaluations
5. Interim project presentations, reports and several evaluations
6. Final project presentations, reports and several evaluations
7. Prototype demonstrations and several evaluations

**ID:** Unlike traditional design studios managing one or two projects within a semester, this collaborative study provides a yearlong project with interdisciplinary team members. Because of new learning contents and contexts, students are required to produce the following outcomes.

- Weekly studio meetings for design ideation and implementation (design ideation, 3D mock-up exploration, visual document, weekly journal)
- Weekly discussions with the interdisciplinary teams for research development (team report)
- Mid-term presentation (research process, findings, design problem statement, design concepts)
- Design critics (every 3 weeks, design boards, scale mock-ups, and 3D renderings)
- Final presentation (design process, final design solution, design storytelling, working prototype)

The final design outcomes will be demonstrated in a gallery with team presentations to all faculty members, students, invited jurors, Industrial Advisory Board members, and industry guests. Students will submit the followings in hard and soft copies:

- Team: graphic boards, working prototypes, computer rendering and/or simulation, design process book, team reports
- Individual: sketchbook, weekly journal

The rubrics used and the preliminary tabulation of raw data are discussed in the next section.

Assessment and Preliminary Results

The authors have developed and administered several rubrics in order to assess the student learning outcomes effectively.

Each discipline had its own set of rubrics adequate for their courses. In cases where the same rubrics were used in both courses, they were tallied separately and then they were combined.

For the purposes of the collaborative research, several rubrics were used.

The first and second rubrics, called peer-in-class evaluation were used by both groups when the CETE students were presenting (Appendix A, Table A), and when ID students were presenting (Appendix A, Table B). The third rubric was used when CETE students were demonstrating their prototypes (Appendix A, Table C) prior to the final project presentation and evaluation.

The following tables illustrate the final averages in a raw format. The final paper will have additional data with complete analysis of the results. Table 1 through Table 3 show samples of the combined CETE and ID teams’ evaluations in Fall 2010. In this collaborative experience, there were 15 students from CETE and 14 students from ID.

<table>
<thead>
<tr>
<th>Combined Evaluations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pre-Final Presentation Peer-in-Class Evaluations</strong></td>
</tr>
<tr>
<td><strong>Date:</strong> Nov 30, 2010  <strong>Time:</strong> 1PM to 3.00PM</td>
</tr>
<tr>
<td><strong>Average</strong></td>
</tr>
<tr>
<td>Team 1</td>
</tr>
<tr>
<td>Team 7</td>
</tr>
<tr>
<td>Team 8</td>
</tr>
<tr>
<td>Team 9</td>
</tr>
<tr>
<td><strong>Total Average</strong></td>
</tr>
<tr>
<td>(Max.pts.=40)</td>
</tr>
</tbody>
</table>
Table 2: Peer-in-Class Evaluations, ID Teams Presenting

<table>
<thead>
<tr>
<th>ID Design Review Evaluations</th>
<th>Date: Nov 11, 2010 Time: 1PM to 3.30PM</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Combined Evaluations</strong></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>Team 1</td>
</tr>
<tr>
<td>Team 1</td>
<td>22.5</td>
</tr>
<tr>
<td>Team 7</td>
<td>26.4</td>
</tr>
<tr>
<td>Team 8</td>
<td>24</td>
</tr>
<tr>
<td>Team 9</td>
<td>26.5</td>
</tr>
<tr>
<td>Max = 30</td>
<td>25.63</td>
</tr>
</tbody>
</table>

Table 3: CETE Teams Prototype Demonstration

<table>
<thead>
<tr>
<th>Pre-Final Presentations - CETE Prototype Demonstration Evaluations</th>
<th>Date: Nov 30, 2010 Time: 3PM to 4.00PM</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Combined Evaluations</strong></td>
<td></td>
</tr>
<tr>
<td>Average (Max. points = 25)</td>
<td>Team 1</td>
</tr>
<tr>
<td>Team 1</td>
<td>20.17</td>
</tr>
<tr>
<td>Team 7</td>
<td>22.61</td>
</tr>
<tr>
<td>Team 8</td>
<td>23.43</td>
</tr>
<tr>
<td>Team 9</td>
<td>24.67</td>
</tr>
<tr>
<td>Average</td>
<td>23.57</td>
</tr>
</tbody>
</table>

Challenges

This initiative turned out to be quite challenging not only for the students but also for the graduate assistants and the advisors alike. Since this was a pilot phase of a one year project, there were many lessons learned and many midcourse corrections to keep everyone motivated and engaged. Some of challenges to overcome included timely completion of the tasks by the students, greater communications between the teams, and most importantly, working in a team environment that brings the students closer to a real-world project teams.

Future Plans

In the spring 2011, the teams will be formed by grouping CETE students in the ELET 4308 (the proposal phase) with the ID students in the INDE 3501 (the Design Studio V). Since each design studio class is offered once a year, as opposed to the CETE sequence courses which are offered every spring and fall semester, the authors developed a sequence of collaborative research shown in Figure 1. The authors planned to follow this table past the completion of the grant period through the support from both colleges.
Conclusions

This paper presented an interdisciplinary collaborative research for senior students in the Computer Engineering Technology and the Industrial Design. Both courses are considered part of the capstone design classes in the two programs. The authors have piloted the project, the preliminary results were obtained, and the analysis of the design is underway. It is too early to draw any concrete conclusions about how students will use the experience gained once they start their professional careers. The authors plan to continue communicating with the seniors after graduation to gauge how effective the experience had been.

References


### Appendix A

Table A: Peer-in Class Evaluation, CETE Teams Presenting

<table>
<thead>
<tr>
<th>Evaluation Categories</th>
<th>Team 1</th>
<th>Team 7</th>
<th>Team 8</th>
<th>Team 9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Idea</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technical Contents</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Degree of Project Completion</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Usage of Time</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Presentation Quality</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project Construction Quality</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Answering Questions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall Quality</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Points</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Instructions to complete the form:**
1. Please write your name and team number at top of the form.
2. Please place an X in the column for your team number.
3. Total possible points for each team are 40. Maximum possible points per cell are 5 points.
4. Points must be assigned on the scale of 5 to 1 for each category (see below).
5. Please add each column and write the sum in the Total Points cells.
6. Please return the completed forms to the graduate assistants.

**Excellent- 5, Good- 4, Average- 3, Below Average- 2, Poor- 1**
Table B: Peer-in-Class Evaluations, ID Teams Presenting

### Peer in Class Design Review

*Your name: ____________________________  Your Team No: ________

Excellent 5, Good 4, Average 3, Below Average 2, Poor 1*

<table>
<thead>
<tr>
<th>Evaluation Categories</th>
<th>Team 1</th>
<th>Team 7</th>
<th>Team 8</th>
<th>Team 9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design Research (market, user, business, and product function)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Design Opportunities (originality, creativity)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manufacturability (materials, production methods)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Design Form (usable, useful, attractive, Appropriate, interactive)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Presentation (graphic board, models)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Answering Questions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Points</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comments
Table C: CETE and ID Teams Demonstrating Prototypes

### Prototype Demonstration Evaluation Form

**Course:** ELET 4209 Project Group, Fall 2010  
**Your Name:**  
**Your Team No.:**

(Please print)

Please remember that you are not evaluating your classmates or friends, you are evaluating technical teams and evaluating them professionally based on the rubrics below.

<table>
<thead>
<tr>
<th>Evaluation Categories</th>
<th>Team 1</th>
<th>Team 7</th>
<th>Team 8</th>
<th>Team 9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardware</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Software</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Workmanship</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Degree of Completion</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Demo (worked, did not work)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Additional Comments</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Instructions to complete the form:**
1. Please write your name and team number on top of the form.
2. Please place an X in the column for your team number.
3. Total possible points for each team are 25. Maximum possible points per cell are 5 points.
4. Points must be assigned on the scale of 5 to 1 for each category (see below).

   **Excellent- 5, Good- 4, Average- 3, Below Average- 2, Poor- 1**