Experimenting with Course Design and Discipline Integration in an Applied Environment

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ABSTRACT

Many faculty members have thought about a truly interdisciplinary applied class. This is the case of a dream that came true across two universities, six colleges, three faculty members, and one corporate business partner. Here was the opportunity to design a course with interdisciplinary faculty and applied mentors from the business partner working together. It is a chance to see if a course design can really help with interdisciplinary thinking, applicability, and relevance while engaging the community. It offered the chance for experimental program integration. The program has been run once and some of the results are outlined below in the paper. Many dream of innovating in education, but few get the chance offered to these participants.

Keywords: business partner, course design, innovative program, program integrations, application, interdisciplinary, community engagement, relevancy

INTRODUCTION

In the Spring of 2016, faculty from two universities and three colleges, along with mentors from an industry partner developed and offered an interdisciplinary class focused on new product innovation. The students taking the class were from six colleges in the two universities. The faculty, in various combinations, had worked together for several years. They often talked of a course that would integrate many disciplines and thus integrate material across disciplinary lines. The hope was to do this with a strong local business partner.

In 2015, a strong local business partner with experience in working with university teams from across the country presented the opportunity to make the vision a reality. The design college graciously provided a physical meeting space proximate to both universities and to transport. The faculty were able to recruit an interdisciplinary group of participants through a combination of structured classes and independent projects. Some were focused on the credit, but most were focused on the opportunity to participate in this new venture and a résumé builder.

In the second week of January 2016, all was ready for the kick-off of the dynamic new course that would challenge all who were involved, students, faculty, and professional mentors.

PREVIOUS RESEARCH

Classes designed to teach students how to collaborate across disciplines in order to develop new products have not been widely adopted in the United States. Unfortunately, this runs counter to trends in professional practice of business professionals, industrial design professionals and engineering professionals. One of the better-known programs is Lehigh's integrated product development program (Ochs, 2003). In this program, teams of engineering students, business students and design art students work with external sponsors to design and prototype new products. Lehigh University is fortunate to have departments of business, engineering and design arts all within the University (Ochs 2006). Multidisciplinary product development has also occurred when students from business and engineering programs collaborate with medical professionals to design medical devices. Since the medical device field is technically complex, highly-regulated and inherently interdisciplinary, solving medical device design problems requires expertise from many different fields. One example of such a program is the University of Alabama at Birmingham's program that involves business students, engineering students, and clinicians in a year-long effort to develop new medical devices (Eberhardt, 2016).

WHY?

There are several reasons why this project was undertaken by the faculty, participants, and by the staff of the client. Industry today is working interdisciplinary or cross-functional teams. Colleges and universities tend to be organized in silos of academic work. Often, not only are they separated in university organization charts, as in the case of the authors' university, but also physically separated by buildings, space and even campuses. It is in the interest of

business and other organizations to help prepare students to work across the disciplines. Young people with degrees will be assumed ready for this kind of work when they graduate.

The project also fits well with university goals for interdisciplinary learning, application, relevancy and community engagement. The project is an applied experience working with professionals, from the client, on their real work opportunities. The engagement of the business partners or client in this case was serious and included a huge time investment on the part of their employees. It was also community engagement as the two universities were engaged across their normal territorial borders. The project seemed very relevant as the participants tackled current problems in the industry.

Course Design

The framework for the course design was built around the five agreed-on meetings at the client location. These are outlined in Table1. In addition to this framework of scheduled meetings were weekly meetings held in the design college classroom dedicated to that purpose. These weekly Tuesday night meetings usually involved one or a combination of three principle activities. First, faculty would use the time to provide structure to the course or to the projects, develop some background material or related terminology across the disciplines. Second, time was used with the business partner mentors. The mentors would drive the hour or so to the campus to spend time with the participants to try to help them improve their thinking as the participants were moving through their projects. Third, was work time for the teams to work with faculty in the room available for questions at any time.

In addition to basic milestone presentations outlined in Table 1 and the Tuesday night meetings, there was an expectation of work on Blackboard usually due on Fridays at noon.

Table 1 Framework for Course Design

Date	**Topics Presented**	**Weeks**	**Developmental Phase**
Jan 15th	**Client presents topics of interest**	1 week	**Introduction**
Feb 12th	**Each group presents:** **Exploratory research** **Three, "we believe," statements** **Three problems or opportunities**	4 weeks	**Exploratory Research**
March 18th	**Present three ideas**	5 weeks	**Context and Experience for three ideas**
April 1st	**Selection of one idea from three**	2 Weeks	**Presented three ideas**
April 22nd	**Final Presentation**	3 Weeks	**Product and Plan**

Introduction Phase

In this week of set-up of the class, the participants got to know all three spaces for operation: the assigned class room, the client space, and finally the Blackboard site for class communication, assignments etc. They also had introductions to the leaders on the client side, the three professors, and the course administrator who was a student volunteer who would keep notes of class discussions to post on Blackboard, chase down missing items, and generally help get things done. The participants were also placed in their teams named for major cities.

At the first client meeting, the topics were introduced. The teams had time to discuss and decide which topic(s) most interested them. The client presenter gave them a lot of freedom in the choice, making it clear that the teams did not have to cover every topic. The topic choices are below by city name of the team.

Buenos Aires -- Privacy
Detroit -- Hacker
Dubai-- Biophilia
New York-- Mobility
Paris-- Mobility
Tokyo-- Biophilia

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Exploratory Research

The exploratory research phase lasted for four weeks. The groups were supposed to investigate in both secondary and primary research, what has been done and what is needed. In the working sessions, there were discussions about where to find information on what has been done, and how to observe and interview people about opportunities in any of the four areas being studied for the client. The technology of today and the potential to take movies and pictures became a powerful tool in the primary research and soon their spaces in the dedicated room became filled with key pictures and observations.

The goal of this section was to come up with at least three supported, "we believe," statements. These are statements that the team developed as they investigated, observed and studied the topic areas. From those statements, they were to develop three opportunities or problems that they could work on. The attempt here is to keep the mind open and not settle on one idea too rapidly. Second, the research helped the participant teams to present their beliefs and opportunities with support in the form of statements, pictures, renderings, videos, others research, etc.

The face-to-face class times were dedicated to the client and faculty teams asking hard questions. Examples of posed questions included, "How do you know that?," "Have you observed the same thing in multiple locations?," "What have others proposed as a solution to this problem?," "Is this problem strong enough to build a product around?," "Does this fit with the image of the client company?" The spirit was always in helping the groups to be more open and to think more clearly about the topics that they were exploring.

In the rich discussion after the presentations, the teams were encouraged to think through if they really had three different opportunities and if they had enough support. Should the team replace one or more opportunities? This was done as business partner professionals moved from participant team-to-team and shared their perspective. The teams were left with challenges as the client mentors did not always agree, and posed questions from different directions. This provided quite an education compared to the normally unidirectional classroom lecture.

Context and Experience

This section lasted five weeks, including a week of vacation for spring break for many of the participants. The goal of this section was to focus on three ideas. Research was continuing along with developing mockups to present. Ultimately, the groups were to develop for each of three ideas with the following:

Product Name

Photo of context or environment of use

Description of the product

Visual sketch of the experience

How would customers use the product?

How does the product work?

Create and demonstrate use with a mockup of the product

The day of presentations was exciting as the room filled with 18 product mock-ups from small to large. Groups presented the context and product ideas to client groups at separate tables. This permitted more intimate viewing of the product than in the front of the room. The reviewers could touch, and in some cases, try operating the mock-ups. Two or three client professionals would give feedback at a time. The clients would rotate amongst the participant groups about every twenty minutes. At the end of the day, the groups had ideas on how to improve the thinking, or, decided to make changes in their portfolio of three products.

During this five-week time period, the meetings with faculty and clients were challenging the participant groups to make the context very clear and to focus on one major opportunity. The meeting previous to the presentations was quite intensive as the client professionals asked hard and focused questions. If this is such a universal problem, where is the support? These client meetings with the groups occurred approximately every two weeks throughout the semester.

Presentation of three developed ideas
This section lasted two weeks. The goal of this section was to develop each of three ideas fully. In some teams, they were iterating as one or more of their ideas no longer seemed strong. This happens at any point in the process. The idea of iteration seems simple in class lectures, but when you actually have to put an idea you have developed down and go back several steps to another idea and do the work to bring it forward, it has new meaning. The faculty were willing to let the teams simply reduce the number of ideas they were looking at but the business partner mentors stood firm and the team members learned a lot.
The presentation to the business partner mentors started as always with the problem and the context or environment of the problem. Hopefully, the presentation of the problem was stronger with each presentation. The teams were trying to assure the strength of the need or desirability. One of the new elements was the investigation of reactions to the models or mock ups as they are presented to potential users. A second new element to these presentations was the engineering feasibility calculations. Suddenly the groups were having to deal with feasibility, the reality of thinking about making the proposed product and what it would take to make it work. Significantly, this requires thinking about safety, durability and many other issues that were not essential parts of early sketches. The third part of this presentation was the need to develop some specifics of the business side of the proposed product, or viability. How big is the market segment and what is it like? What competition exist (direct, indirect, substitutes), or may be forth coming based on research? What are the projected sales? All of these factors and the others listed below were designed to lead the groups to think about which of their ideas were the best.

Photo(s) of problem

Photo(s) of context of problem

Sketch of Solution to problem

Sketch of use case experience

Photo of mock up being presented

What was learned presenting to people?

Engineering feasibility calculations

Target market size, and persona

Competition in the market

Value proposition

PLC one to seven years

Groups recommendation of one to develop
At the end of the day of presentations, the teams selected one product based on all the comments to continue for the final three weeks. The participant groups worked hard to pull together all the information required. The goal was informative presentations that would make a clear case for each product. Then, with the help of the mentors, the final choice could be made.

Product and Plan
The groups had three weeks to bring it all together in a coherent presentation with a realistic mock up or early stage prototype. The challenge of these three weeks was to clearly justify the need or desirability of the product, to make the engineering case for feasibility, and to make the business case for viability. Below are the expectations for the final presentation.

What we are about and "Why?"
Market Trends – What drives demand?
Key observations in context
Behaviors/Attitudes (context/action photos)
Target Problems and how to evidence
Solutions – name, benefit, renders w/ user
Application render in context – "In use"
Feasibility

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Inspiration
Mechanical and technical function
Manufacturing Process
Materials
Exploded view w/ B.O.M.
Cost estimates
Performance Specifications
Eng. Calculations
Mock up concept
Photos of demonstrations in context
Validation – "What did you learn?"
Target market – Define size and persona
Sales Trajectory – "PLC" in unit sales
Competitive positioning
Unique Value proposition

The final day of presentations were held at the client's location and the students brought their refined models of their products.

ASSESSMENT OF LEARNING OUTCOMES

The following four learning outcomes were defined and assessed:

1. Students will be able to work effectively in interdisciplinary teams.
2. Students will be able to describe the roles of different disciplines in the product innovation process.
3. Students will be able to learn from practicing professionals.
4. Students will be able to apply knowledge from many different sources to formulate solutions to an unstructured problem.

Qualitative assessment data was gathered from a focus group and quantitative assessment data was obtained using survey. At the end of the program, one of the professionals who had been affiliated with the corporate partner before retirement volunteered to moderate a focus group with the students about the class. The moderator was well-known to the students because she had participated in several critique sessions with the corporate mentors. The faculty were not present when the moderator carried on a free-flowing discussion about the process, the teams, the work, what they learned, etc. Student remarks were recorded by the administrative student. Remarks that were relevant to the learning outcomes are presented below.

The quantitative assessment data was gathered using a Student Assessment of Learning Gains (SALG) (Seymore, 2000) survey which was administered at the end of the program. Twenty-five of the 26 students in the class participated in the survey. In this case the reporting is on those questions that were objective and answered in a Likert scale format. This was a one-to-five form where one was low and five was high. There were a total of 38 questions, of which some were qualitative. The authors selected the average of questions that were relevant to the learning outcomes of the class.

Outcome 1: Students will be able to work effectively in interdisciplinary teams.
The following comments relating to outcome one were recorded at the focus group.

1. It was cool to see how the three disciplines work together, gives a real world perspective while in a college setting. One of the most important part of the project.
2. Really nice to see the other side of product development, didn't need to see the nitty gritty of it all.
3. The wildcard (majors other than business, design, and engineering) was also beneficial to offer a unique perspective.
4. Most important thing: the feedback from the client (learned something every time they talked) and also the involvement was getting to work with all the different disciplines, learned how to communicate information effectively between the different disciplines.

Table 2: SALG survey questions and averages responses relevant to outcome 1.

Question	Average
As a result of your work in this class, what gains did you make in your skill of working with people from other disciplines?	4.35
As a result of your work in this class, what gains did you make in your skill of applying the techniques and concepts from your discipline to an interdisciplinary project?	4.13
As a result of your work in this class, what gains did you make in your skill in Assessing differing perspectives in decision making?	4.13
As a result of your work in this class, what gains did you make in your comfort level in working on complex interdisciplinary problems?	4.27
As a result of your work in this class, what gains did you make in your belief that interdisciplinary thinking is necessary for success in your career?	4.55
How much did working with peers outside of class help your learning?	4.14

It is easy to see that the participants reported getting a great deal out of the interdisciplinary work both in the qualitative discussion group and in the more quantitative Student Assessment of their Learning Gains. In the qualitative section, there is a reference to the "Wild Card" members of teams. Each participant team contained at least one person from each of the following disciplines: business, design, engineering; in addition, there were other participants from a variety of majors in the college of arts and sciences, and from the college of interdisciplinary studies.

The client feedback has been included here as well as it was very interdisciplinary in nature. Some of the areas of the client mentors included: business, design, engineering, research, ethnography, etc. These interdisciplinary mentors helped to make important contributions to the participants. The questions were designed to look at the interdisciplinary learning and application in several ways. First, could you apply your discipline to an interdisciplinary problem. Second, did the participants improve at looking at things from different perspectives. Third did you make gains in addressing the complexity of interdisciplinary problems. Do you see the importance of interdisciplinary thinking in your career? This was one is very important. If the participants can grasp this, then the door is open for new thinking into the future.

Outcome 2: Students will be able to describe the roles of the different disciplines in the product innovation process.

These are students' comments as recorded by the student administrator for the project.

1. Nice having the experts in their field, but there was conflicting feedback.
2. Would have liked to learn more from the (three different) professors with lectures, a lot of time on design. Profs should have spent more time lecturing. (Some disagree with this.)
3. Enjoyed working with *my design professor* on project, didn't work with other professors too much because people focused on their corresponding professors.
4. Respect was a major force to resolve. Wasn't too much arguing in the beginning, more was directed towards the end.
5. Professors worked well together.
6. Liked that there was a workplace always there to utilize and it was almost personalized by team to feel like it was their area. Also, people liked being able to see the progress of ideas.
7. Posted pads were a bit messy and PowerPoints/ Blackboard were more used for information from Professors. However, it was good that you could always go back to the board and see what was done and what you missed. Both ultimately good because we were very mobile.

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Table 3: SALG survey questions and averages responses relevant to outcome 2.

Question	Average
As a result of your work in this class, what gains did you make in your understanding the roles of different disciplines in product design and innovation?	4.63
As a result of your work in this class, what gains did you make in your understanding the relationship between a product's desirability, engineering feasibility and business viability?	4.35
As a result of your work in this class, what gains did you make in your confidence that you understand the innovation and design?	4.09
As a result of your work in this class, what gains did you make in Identifying multiple approaches for solving a problem in a given context?	4.05

The silos of the campuses are problematic for student learning and preparing for the world of work where they must work across the disciplines. In this case, the authors were really interested to see how the participants felt about moving across the silos both physically and topically.

It is interesting that while they felt the professors worked well together, that they would have liked to learn more from each discipline. Perhaps in the effort to create a real-world experience, taking the role of coaches or facilitators did not provide enough discipline content.

The issue of respect is important. There were some very different styles of working together in the teams. One had to do with timing and planning. This became evident at the end when some people were willing to do anything to drive to the finish line with a product and a plan and others did not feel that push.

In the objective portion, there was again strong support, particularly in understanding the importance of the roles of different disciplines which is crossing the silo topically.

Outcome 3: Students will be able to learn from practicing professionals.

These are students' comments as recorded by the student administrator for the project.

1. Most important thing: the feedback from the client (learned something every time they talked).
2. Disconnect from what was asked by the client's professionals and what was asked by the Professors made some situations uncomfortable.
3. Nice having the experts in their field, but there was conflicting feedback

Table 4: SALG survey questions and averages responses relevant to outcome 3.

Question	Average
As a result of your work in this class, what gains did you make in applying what you learned in this class to other situations?	4.00
How much did getting activities at the corporate sponsor's location help your learning?	4.27
How much did discussions with corporate staff in the college's project room help your learning?	4.59

Community engagement is a term of university faculty and administration and is not a focus of students other than they seem to like things that are real world and applied. In this case, there were two kinds of community engagement: direct with the business partner or corporate client, and, indirect with the participants going out into the community to investigate problems in the empathy or ethnography stage, potential solutions and validation of an idea. Finally, there was the validation of the selected prototype.

In the discussion group, there was not much on this topic. However, in the Student Assessment of their Learning Gains there was a very favorable reaction to being on-site at the corporate location and on getting the corporate mentors input on campus. There is support for the direct engagement.

This may be a weakness in the data collection as the participants spent a lot of time in other organizational environments watching, taking pictures, talking, trying to understand the problems that people were facing that could be solved by the teams.

Outcome 4: Students will be able to apply knowledge from many sources to formulate solutions to an unstructured problem.
These are students' comments as recorded by the student administrator for the project.

1. Gives a real world perspective while in a college setting. One of the most important parts of the project.
2. Most important thing: the feedback from the client (learned something every time they talked).
3. Disconnect from what was asked by the client's professionals and what was asked by the Professors made some situations uncomfortable.
4. Nice having the experts in their field, but there was conflicting feedback

Table 5: SALG survey questions and averages responses relevant to outcome 4.

Question	Average
As a result of your work in this class, what gains did you make in your understanding the concept of validation?	4.17
As a result of your work in this class, what gains did you make in your understanding of problem identification?	3.9
As a result of your work in this class, what gains did you make in your skill in formulating a novel approach to a problem?	3.87
As a result of your work in this class, what gains did you make in connecting key ideas with knowledge learned in other courses?	4.00
As a result of your work in this class, what gains did you make in drawing conclusions from examples, facts, models, and/or theories from more than one discipline?	3.86
As a result of your work in this class, what gains did you make in applying what you learned in this class to other situations?	4.00

In terms of application, the participants were loud and clear that they got a lot out of working with the corporate or business partner mentors. They liked the real-world perspective and the professional feedback. What they struggled with was the lack of consistency, particularly with the professors. In the objective data from the Student Assessment of their Learning Gains, it was positive, but not as strong as in some of the other area. The same seems to be true of the only two questions that were focused on relevancy.

CONCLUSIONS

For the authors, this was a realization of a dream to attempt this kind of project across universities, colleges, and including the corporate world.

The participants seemed to get a lot out of it in several ways. First, as the reader has seen above from their responses in the discussion group and on the Student Assessment of their Learning Gains, the participants showed an overall positive response. Second, they also seemed to get a lot out of it in the form of a résumé-builder as anecdotally they have used this project to open doors for themselves as leaders in a variety of fields. The engineers continued with the corporation to work on further design and prototyping. Some of the participants are doing incredible things, for instance, one participated in National Science Foundation Program in the summer of 2016 in a national competition and did very well. The team is now seeking grant funding for a project. Another has ongoing research in the same industry. Overall, the participants got a lot out of the program and would have it offered again with minor modifications.

The faculty really enjoyed the program but have significant trouble with the workload involved. Dyadic interdisciplinary team-teaching is tough enough as you really have to prepare to use each other's strength. When you make that a triad and consider the different teaching cultures, (even across universities), it gets more complicated and requires more time and thought. In this case, there was not only a triad of professors, but the entire business partner mentor group of excellent and dedicated professionals.

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These corporate mentors were extremely generous with their time and knowledge, often driving snow filled roads to spend two hours with the participants. As observed above, they also came from different disciplines.

This became a real challenge as faculty working with the participants. The young participants would like one answer and yet they could often get multiple perspectives on the same issues. Professors would then have to facilitate the teams making a choice without becoming the guide.

In short, for faculty it was time, mental time, physical time (more class meetings, and travel to corporate client for meetings etc.), team time, which all added up for each individual. In the first program, it was largely uncompensated time which raises a larger issue for colleges and universities.

An educational institution wanting to run a program like this needs to think about the cost. The final program size was 26 participants with 24 paying tuition to one of the universities. It used three faculty members, a dedicated classroom space, and supplies, etc. which were provided by the design college. The classroom was pulled out of service for other classes. A university administrator would have to look at the total cost and consider how in future generations of the program to develop a sustainable funding model.

The experiment in course design and discipline integration in an applied environment was a rich experience, a great success for participants and faculty. The challenges are really how to move forward and are there ways to do that to reduce the cost impact.

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