ABSTRACT
Connecting the fields of engineering with business and entrepreneurship in higher education has yielded a wide range of innovative and useful outcomes, products, and organizations. This paper advocates extending these connections to include additional academic disciplines—specifically Arts and Sciences— or the purpose of increasing the number and variety of ideas, problem-solving approaches, and innovations. The paper also provides the results of an exploratory quantitative analysis, as well as examples of programs and student projects.

Introduction
Engineering and business disciplines have long been connected in industry and professional practice, and a number of academic programs have followed this trend with cross-disciplinary academic programs. Over the past 20 years, Arts and Sciences fields such as anthropology have made important contributions to our understanding of the adoption of innovations, market research, and buyer behavior. IDEO is an award-winning global design firm that helps organizations in the public and private sectors to innovate and grow, and was among the first to develop and employ an interdisciplinary approach to problems: “human centered design.” IDEO’s 550+ employees have been trained in a variety of fields: anthropology, communication, engineering, healthcare, marketing, psychology, and industrial design (IDEO n.d.). Despite these developments and successes in industry, academic programs have not yet followed suit.

Triarchic Theory of Intelligence
An interesting series of studies by Sternberg (1988; 1997; 2006) proposed a model of intelligence referred to as the triarchic theory. According to this theory, there are three major types of intelligence: (1) analytical, the ability to solve a problem by looking at its components; (2) creative, the ability to use new or ingenious ways to solve problems; and (3) practical, referring to street smarts or common sense (Sternberg et al. 1995). Programs that blend engineering with business give students the analytical and practical components of problem-solving, but perhaps we can gain even more by including fields from the Arts and Sciences to complete the trifecta.

Sternberg underscores the importance of using all three types of intellectual skills by highlighting the difference between academic problems and real-world, practical problems:

...the characteristics of academic problems tend to be (a) formulated by others; (b) intrinsically uninteresting for the most part; (c) self-contained, in that
Arts and Sciences disciplines such as english, history, sociology, art, journalism, psychology, political science, film studies, and education frequently address difficult and complex issues and problems and train students to successfully address them as well. Consider how the range of possible solutions to a problem in the local or global community might expand if students from very different majors teamed up to address it: chemical engineering with museum science; biology with management of information systems; film studies with education; sociology with finance; art with geology. Many innovations have resulted from combining fields (e.g., biomimicry); our team decided to look for more ways to build on this idea.

There are two more reasons that universities should embrace Arts and Sciences disciplines during the innovation process. First, 77% of US college students are pursuing majors in non-STEM (science, technology, engineering, and mathematics) fields (US Department of Education 2011). And second, given the high rate of underemployment of non-STEM graduates (over 8 million), students in these majors appear to need additional help to better prepare for careers in industry. It is natural for our nation to increase our innovation capacity and potential by working with the talent in our universities, but efforts to date have ignored a cohort with great potential. Despite the fact that most US college students are pursuing degrees in non-technical majors, innovation-related funding and curricula for post-secondary programs has been almost exclusively directed to programs serving technical majors. Students studying in fields such as economics, exercise science, design, and history represent a potentially powerful force for innovation, but these majors often receive no training in that discipline. An additional set of hands-on, applied experiences and coursework in innovation for these students will help non-STEM disciplines join our nation’s innovation revolution and improve job prospects.

“High-Impact” Teaching Tools

The NSSE Annual Results 2010 report states: “Because of their positive effects on student learning and retention, special undergraduate opportunities such as learning communities, service-learning, research with a faculty member, study abroad, internships, and culminating senior experiences are called high-impact practices” (Kuh 2008, National Survey of Student Engagement 2010, 22). High-impact practices share several traits: “They demand considerable time and effort, provide learning opportunities outside of the classroom, require meaningful interactions with faculty and students, encourage interaction with diverse others, and provide frequent and meaningful feedback. Participation in these practices can be life-changing.” (NSSE 2010, 22).
Our interest was in developing a program that was more than service learning. Service learning gives students direct experience with issues they are studying in their curriculum; however, we wanted students to innovate within their area of expertise, building upon their knowledge base to solve problems for community organizations. Our plans involved more than an internship experience because we wanted students to be active consultants and participants in the organization’s strategies, rather than part-time workers.

The Applied Innovation Certificate

With this motivation, our department set out to develop a curriculum that would equip technical and non-technical college students with a more complete set of knowledge, skills, and experiences necessary for them to innovate. We started by developing a physical space (Studio Blue) in which we tested the human-centered design process on client projects over a three-year period. Then we developed a series of three sophomore-level core courses that would give students the tools and the hands-on experience of developing innovations in their chosen field of study that would benefit real-world organizations.

In 2007, the university invested in an on-campus facility and student resource called Studio Blue, which has effectively served as a four-year pilot program in teaching undergraduate and graduate students a three-phase approach to innovation and given them the experience of innovating and implementing a project that benefits a community organization. We have regularly gathered interdisciplinary groups of students to collaborate on projects for a range of local for-profit and not-for-profit organizations, using techniques proven successful in industry. Funded in part by an outside charitable foundation, Studio Blue has benefited many organizations, been recognized in the media, and has won two ADDY awards. More information is available at: www.utulsa.edu/studioblue under the Project Portfolio link. Past clients include:

- For-profit organizations: US Cellular, Mazzio’s Italian Eatery, Nordam.
- University departments: Admissions, Alumni Association, and Community Outreach.

The certificate’s three core courses are Innovation and Qualitative Methods, The Entrepreneurship Experience, and Practicum. When combined with a freshman block course and a general education elective, students are eligible to receive the Applied Innovation Certificate. Because it was established as a university-level certificate (not resident within any one college), students from any major may pursue this certificate at any time. Aside from benefiting Arts and Sciences students, the experiential and personalized nature of the courses was expected to improve the likelihood that high-need students would complete their degree, that the projects would offer substantive benefits to local business and non-profit communities, and that we would increase students’ learning outcomes and improve their prospects for successful employment. If an interdisciplinary certificate program like this were adopted nationwide, and assuming that 50% of non-STEM majors completed the coursework, the number of university students capable of participating in the innovation
process would increase from 23% to at least 60%, which in turn would benefit all types of organizations in which they might be employed.

Research in educational psychology supports the “human-centered-design” approach to learning and discovery. John Dewey’s early model of education included three principles: experience, inquiry, and reflection (Giles and Eyler 1994; Dewey 1938). Reading literacy has three subscales: access and retrieve, integrate and interpret, and reflect and evaluate. Kolb’s (1984) experiential learning model represents a three-step cycle or spiral where the learner moves through a process of experiencing, reflecting, thinking, and acting. The first and last phases of the cycle are the same, because the process is iterative in nature.

An Exploratory Test
IDEO’s “human centered design” process was taught as a problem-solving approach in an MBA class at a midwestern university to help the students work on a project for a local non-profit organization. The 20 students came from a variety of undergraduate majors. At the beginning of the semester, they were given a brief self-report questionnaire (see Table 1) on their impressions of how well-equipped they felt they were to help a local small enterprise in a number of areas. When the course was over, students were given the questionnaire again and also asked to identify any changes that occurred in their learning over the entire course. Because the sample size was so small, the statistics from this exploratory test can only be considered preliminary. When the pre-class and post-class means were compared, 9 of the 20 study items displayed significant improvement (see Table 2). Overall, these preliminary results show that students can improve in several practical, hands-on competencies as a direct result of a pedagogical approach using the “human centered design” process. However, additional empirical work is needed to validate these findings.

The Nova Fellowship
Based on the qualitative and quantitative evidence supporting the use of this pedagogical approach, we decided to pilot another idea that would expand innovation training to all undergraduate majors. For students who want to receive a deeper level of training in innovation, our university now offers the Nova Fellowship (Fall 2012). Funded by an external grant, this program intentionally combines professionals in the local community with faculty and students from each college on campus to develop meaningful projects for the community. Students in this program pursue the Applied Innovation Certificate, but also receive additional training, mentoring, and experience as they create and implement projects in the community. Visit www.novafellowship.org for more information.

Conclusion
Since launching Studio Blue in 2008, we have learned–sometimes the hard way–what tends to work and not work with students from a variety of majors collaborating on community projects in an extracurricular setting. Students have been involved with projects benefiting over 50 clients since that time, and aside from helping many worthwhile organizations, their work has been recognized with two local ADDY Awards and several pieces of earned media. In our NCIIA presentation, we will demonstrate a few of the creativity tools
we use, and show some of the student projects. This experience has led us to introduce new programs that teach innovation in ways that are appropriate and meaningful for students from a wide range of majors.

This paper has demonstrated through practical examples of projects for real organizations, and empirically through an exploratory study, that the innovation process can be effectively employed by non-STEM majors. Our current programs are designed to build upon these experiences and develop a national model that we hope can be used by Arts and Sciences programs around the nation. If innovation is understood as not always involving technology, but including process improvement or simply doing things in a more effective or humane way, then more college students can participate and may wish to. If our nation's colleges and universities can tap students' passions, combine forces with other majors to build upon their knowledge base, and implement creative solutions to problems they care about, then they can consider themselves inventors and innovators too.

References


Imagine that you have just been called upon to help a small enterprise in the city -- you will begin immediately. How well equipped do you believe you are – today – to help them in the following areas?

1=Very well equipped
2=Fairly well
3+Neutral
4=A little
5=Not well equipped at all

1. Gathering key information and data about the industry that the company competes within
2. Gathering key information and data about the company's customers
3. Gathering key information and data about the company and its operations
4. Identifying key issues that may be hidden to the owners and may be holding back the business
5. Analyzing data
6. Developing a business strategy for the firm
7. How to understand the firm's customers and gain insights into customers' behavior and preferences
8. Coming up with a large number of creative ideas and potential solutions to the company's problems
9. Giving the firm advice on accounting
10. Giving the firm advice on finances
11. Giving the firm advice on operations
12. Giving the firm advice on marketing
13. Giving the firm advice on how to innovate the business
14. Giving the firm advice on management
15. Your ability to work effectively with others as a member of a consultant team
16. Communicating clearly in writing
17. Communicating clearly in person / speaking skills
18. Designing solutions for the business that are practical, workable, do-able
19. Working alongside the firm to show them how to implement the solutions you propose
20. Using project management skills and processes to help the firm implement solutions
### Table 2: Survey Results

**Scale:**

1 = Very well equipped
2 = Fairly Well
3 = Neutral
4 = A little
5 = Not well equipped at all

**Measures that Showed Significant Increases in Mean Scores:**

<table>
<thead>
<tr>
<th>Measure</th>
<th>Pre-Semester</th>
<th>Post-Semester</th>
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<tbody>
<tr>
<td>Gathering key information and data about the company's customers.</td>
<td>2.54</td>
<td>1.54</td>
</tr>
<tr>
<td>Gathering key information and data about the company and its operations.</td>
<td>2.09</td>
<td>1.36</td>
</tr>
<tr>
<td>Identifying key issues that may be hidden to the owners and may be holding back the business.</td>
<td>2.09</td>
<td>1.55</td>
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<tr>
<td>Analyzing data.</td>
<td>2.00</td>
<td>1.27</td>
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<tr>
<td>Developing a business strategy for the firm.</td>
<td>2.18</td>
<td>1.63</td>
</tr>
<tr>
<td>How to understand the firm's customers and gain insights into customers' behavior and preferences.</td>
<td>2.81</td>
<td>1.63</td>
</tr>
<tr>
<td>Coming up with a large number of creative ideas and potential solutions to the company's problems.</td>
<td>2.18</td>
<td>1.81</td>
</tr>
<tr>
<td>Giving the firm advice on how to innovate the business.</td>
<td>2.18</td>
<td>1.73</td>
</tr>
<tr>
<td>Designing solutions for the business that are practical, workable, doable.</td>
<td>2.09</td>
<td>1.27</td>
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