# ”Impact! Exploring Innovation Across Disciplines” - Engaging the University Innovation Ecosystem Through a University-Wide Course

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# "Impact! Exploring Innovation Across Disciplines" - Engaging the University Innovation Ecosystem Through a University-Wide Course

Innovation can be simply described as the realization of ideas to add value. The goal of innovation is POSITIVE CHANGE, to make someone or something better. Innovation involves a change in the thought process for DOING SOMETHING or new stuff that is made useful. It can often involve incremental or radical and revolutionary changes in thinking, products, processes or organizations. While there are many similarities and interesting differences among the approaches to innovation in various fields, there is always one common element: The strong drive to make an IMPACT. This course examines innovation from an interdisciplinary and integrative perspective. We explore both what makes something innovative and how innovation happens; whether the innovation is a breakthrough product like the iPod; a new water system for developing countries; an engaging piece of music or inspiring work of art; an emotional theatrical event; or a revolutionary film. The course is cross-listed in Engineering, Management, and with a UNIV designation to engage students from diverse backgrounds. Participants have come from engineering as well as art and art history, comparative humanities, communication, economics, education, English, history, management, music and psychology. The course has now been taught for two years. Student reviews have been overwhelmingly positive. But perhaps the more meaningful outcome has come from the course acting as a catalyst for engaging the broader Bucknell University ecosystem in a conversation about our common interest: making an Impact. This paper describes the course organization and content. It also examines the broader impact on the university innovation ecosystem through the engagement of faculty and students from multiple disciplines.

## Introduction

It is class session 23 and Sue Ellen Henry, Associate Professor of Education, is leading a guest "lecture" on her particular view on innovation. With her are two students who worked with Professor Henry to found a student-run non-profit organization they call the Poolpass Project. Also with her are the inspiration for the project, Mr. Rotolo and his minister. Professor Henry tells the story of how she was inspired to start this venture after reading in the newspaper about two elementary school children who drowned in the nearby Susquehanna River one summer afternoon. Despite a newly remodeled and improved public swimming complex in town, the children were swimming in the dangerous river because they could not afford the $4 fee to go to the pool. One child drowned when trapped by submerged rocks in the river and the other drowned trying to save her. Professor Henry thought "How can this happen in such an affluent college community?" So, she met with Mr. Rotolo, who is the father of one of the children and uncle to the other, and his minister to talk about how she could help. The result was a student project initiated in her class on multiculturalism and education that has raised thousands of dollars to sponsor pool passes for local families in need. The Poolpass Project has now passed three years of operation and become a sustainable student-run philanthropic organization [1].

For the eclectic mix of students enrolled in “Impact: Exploring Innovation Across Disciplines” this is one of many class sessions exploring what innovation means to different people and how they go about doing it. For many of them, this class has been a transformative experience where they have learned about the nature of innovation and recognized the important knowledge, skills and character development involved. Through their explorations they have learned that innovation is not easily defined. Innovation goes beyond the creative generation of ideas. While creativity is an asset, ideas, even “good ideas” are not enough. And what makes an idea good? Certainly good ideas provide benefit, but innovation must also consider the expenditure of resources to implement them so that they provide value. Moreover, these good ideas are only beneficial if they are realized for the intended audience. In response, they have settled on a working definition: *innovation is the realization of ideas that add value*. Professor Henry’s Poolpass Project exemplifies that ideal. She saw a problem. Explored ideas in response. And made it happen. She has made an IMPACT. Her story inspires the students to seek their own opportunities to address a need and develop innovative solutions. To themselves make an IMPACT.

Innovation has received a lot of attention lately. President Obama has launched a national Innovation Strategy: "The first step in winning the future is encouraging American innovation. None of us can predict with certainty what the next big industry will be or where the new jobs will come from. Thirty years ago, we couldn’t know that something called the Internet would lead to an economic revolution. What we can do -- what America does better than anyone else -- is spark the creativity and imagination of our people "[2]. Many view innovation as an economic driver. It is often closely linked to other terms such as creativity and entrepreneurship. Because of the link of innovation to new product development, engineering is often closely associated. The National Academy of Engineers was on the commission for the report “Rising Above the Gathering Storm”[3] which highlights the importance of innovation to American competitiveness and draws a close link to engineering and science education. Pundits have continued to espouse the importance of innovation[4] as part of their harbinger of doom for the future of American competitiveness.

For teaching innovation, it is worthwhile to explore pedagogy on product development and entrepreneurship. Many of the techniques for innovation have been integrated into the design curricula of engineering departments with topics on problem recognition and definition, incorporating the voice of the customer, idea generation and evaluation that lead to detailed design[5,6]. Many now implement their senior designs at least to the point of a prototype[7]. Business schools now acknowledge the power of new ventures and have incorporated programs of study in entrepreneurship. In response to the vision of the engineer in 2020[8,9] , many schools have developed courses to promote more business acumen among engineers. Many provide an interdisciplinary experience with engineers working with business majors[10,11,12,13,14,15,16]. Thoughts on innovation have advanced beyond a narrow view of entrepreneurship. Intrepreneurship refers to the application of the same types of principles for innovation within large organizations. Social entrepreneurship describes innovative solutions for societal problems. In recognition of this expanded view, the Kern Entrepreneurship Education Network (KEEN) of roughly twenty engineering programs nationwide seeks to instill the entrepreneurial mindset in students[17].

Clearly innovation and entrepreneurship are not topics limited to the fields of engineering and business. When considering creativity one naturally thinks of the arts. But one certainly can't question the benefit of entrepreneurial principles for a professional sculptor, musician or playwright. Companies have also caught on to the benefits of employing anthropologists and psychologists in their product development efforts. In fact, when considered more deeply, innovation is not specific to any single domain. And perhaps one can argue that the most innovative enterprises occur at the intersections of the disciplines as Steve Jobs suggested at the launch of the iPad[18]..

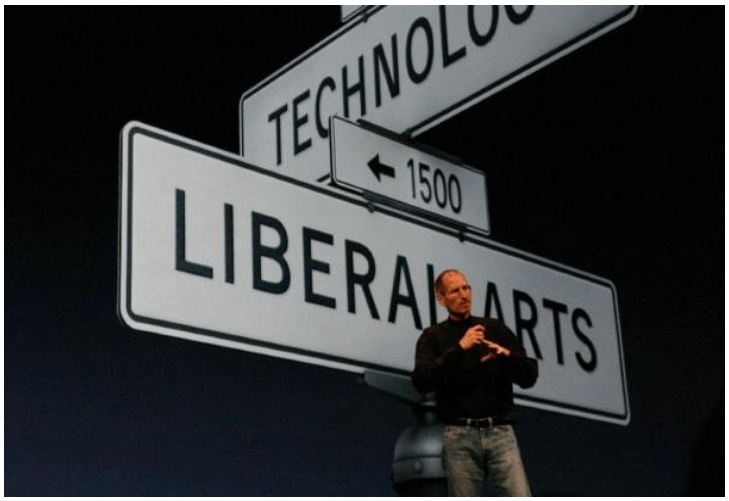


Figure 1: Steve Jobs Highlights Technology and Liberal Arts at iPad Launch

It is clear that our students must be prepared to navigate our flattening world. The Accreditation Board for Engineering and Technology (ABET) requires our engineering programs to provide broader perspectives to our students. At Bucknell University, our liberal arts institution helps to support that with the multitude of classes available to the engineers. But there is actually little opportunity for our students to work together in truly broad interdisciplinary teams. Not just among engineering disciplines or engineering and business, but students from across the liberal arts university. But perhaps even more valuable is the opportunity for students from the College of Arts and Sciences and the School of Management to work collaboratively with students from the College of Engineering.

The philosophy for this course centered on the exploration of the similarities and differences that disciplines use when they approach innovation. We wanted to not only mix up the student backgrounds, but also increase their awareness of the innovative activities that occur across campus. We intentionally place the students outside of their comfort zone repeatedly throughout the semester with the assignments, lectures, and activities. We also wanted to make the course workload challenging so that students felt a strong sense of accomplishment when finished. This expectation was enhanced by requiring students to apply for enrollment by writing a brief essay about why they wanted to enroll. Enrollment was then managed to ensure a broad mix of students from diverse disciplines with roughly half engineers and half others.

We immediately set the tone for the class that students would need to take personal responsibility for their own learning. They were assigned to read a book BEFORE the first day of class and prepare an assignment based on the reading. They started that first day presenting their assignment to the class. The class was intentionally designed to help students build their tolerance for operating outside of their comfort zone. We started exploring innovation within their disciplines and then moved outward. All assignments required students to work with someone outside of their discipline and someone new. We strongly encouraged them to move to new seats throughout the semester (if they were sitting at all). Students shared their work in groups of various sizes and often presented to the entire class. Reflection, self-criticism and constructive criticism of others were integral to all activities. Passivity was not an option. The class met twice per week with two hour sessions. This allowed for flexibility of class activities. Students shared and presented their assignments at each class. All of these various techniques supported an overall active learning method of Problem-based Learning that incorporated both Collaborative and Cooperative learning methods[19](

The course was developed and team taught by Steve Shooter in Mechanical Engineering and Seth Orsborn, professor in the new Markets, Innovation and Design (MIDE) program in the School of Management. Classes were taught in a true partner fashion. While one of us would take the lead on a topic, both of us participated. Instruction was supplemented with many guest lectures and field trips to other areas on campus. These included faculty from Art Studio, Art History, Comparative Humanities, Theater and Dance, Music, Psychology, Education, and Biomedical Engineering in addition to the president of the university. We were overwhelmed with faculty willing to participate and could not fit all of the offers into the course schedule. Additionally we brought in outside speakers from industry. The point is that we recognized that we did not know everything and therefore made no effort to act as if we did.

The following sections will describe the course in more detail by presenting the syllabus topics throughout the semester. We then present the final project assignment and share some of the results. This is followed by assessment of the course outcomes both directly and indirectly. We conclude with reflections on the course and the added benefit of using this course as a driver for uniting the university innovation ecosystem.

## Course Objectives

The course objectives were created in concert over several months with the intent that by not rushing the creation of the course we would build in the most appropriate high-level objectives, mid-level outcomes, and implementable low-level tactics. Since our overall goal for the course is that the students understand what makes something innovative and how innovation happens, we compiled three main objectives: 1) that they would be able to *define* innovation and be able to identify it within context, 2) they would *recognize* the role of the person and the environment in innovation, and 3) they would be able to *demonstrate* the methods employed to realize an innovation of their own. These three main objectives then naturally emerged as three parts of the class, the first two working in series to support the expected activity of the third.

With the implicit objective of guiding the students outside their comfort zone, much of which has been created by traditional learning paradigms, their first assignment was to read Dan Roam's

*The Back of the Napkin*[20] before the semester started and then use what they had learned to communicate to the class something innovative that they had done sometime in their life. This set the tone for a class that was going to be non-traditional and very interactive.

Assessment

We took a non-traditional approach to assessing the students' performance on assignments throughout the semester. We did not assign grades for each assignment because we did not want the students to focus on the grade, but more on what was learned. After an assignment was presented and discussed in class, the students would write a short paper reflecting on their performance and what they had learned. They used techniques Shooter described in his paper on reflection based on the Kolb model[21]. We expected that they would not "get it right" the first time. After they reflected on their assignment, we provided them with verbal and written feedback. As the semester progressed, the students would provide constructive criticism on each other's assignments. The intent was that students would demonstrate proficiency at the end of each course segment.

*Segment 1: Define*

After the Roam exercise on the first day, we then spent the next two and a half weeks (five sessions) exploring various forms of innovation with the goal of being able to define innovation. The students first went and found innovators or innovations in their respective fields and presented to the class why they thought these were innovations. This enabled us to assess what preconceptions the students brought to class which would provide a means for us to create a common understanding, a necessary step as discussed in Pellegrino[22]. Then, as a class, we dug out the similarities between these seemingly unrelated innovations to find the roots of innovation. We then introduced ideation tools to explore what is NOT innovation. This enabled us to define innovation through the absence of it, starting to give form to a definition of innovation, despite it being a rather nebulous concept in most minds. John Hunter, a professor of comparative humanities, provided the class with a historical context of innovation that was supplemented with readings from *Where Good Ideas Come From* by Steven Johnson[23], *Innovation: The Communication of Change in Ideas, Practices and Products* by W. Spence[24], and *The Rise of the Creative Class* by Richard Florida[25]. These readings culminated in a healthy discussion class that provided more clarity for our definition. The students then had to pair off with someone outside their discipline to find an interdisciplinary innovation. This task was rather easy at this point because the general understanding had risen to where everyone agreed that innovation is inherently interdisciplinary. Before settling on our final definition, *innovation is the realization of ideas that add value*, the entire class visited a sculpture studio to explore the variety of materials, or mediums, in which innovation can occur. The primary goal of this trip was to confirm within the students that innovation can come in many forms, most of which they haven't been exposed to in their discipline. The methods described helped to build the conceptual framework in which the students could place the concepts and ideas learned throughout the rest of the semester[22].

The *define innovation* segment involved five assignments. The first was to use the Roam method to describe an innovation they were personally involved with or aware of. The second was to prepare a flash presentation (6 minutes) of an innovation within their discipline. The third was to

identify the roots of innovation from their flash presentation. These first three assignments were done individually. The fourth assignment was to use the Roam method to describe something that is NOT innovation with a partner outside of their own discipline. The fifth assignment was to prepare a six minute flash presentation on an interdisciplinary innovation with a new partner outside of their discipline. These assignments and class exercises resulted in a working definition of innovation. The students then ranked the examples based on their "degree of innovativeness" and explained why. Not surprisingly, their rankings were not all the same. We then assessed the students' proficiency in defining innovation. In both semesters all of the students were proficient with using our working definition of innovation to describe an innovation. They also acknowledged the challenge in establishing a formal definition.

To give the reader a richer understanding of what some of our classes were like, we would like to share a detailed example on the topic of NOT innovation. The class started with the students presenting what they had done for their homework. This was a technique that we used quite often because it forced the students out of their seats and provided the opportunity for all of us to learn from each other. In this instance, they had been asked previously to go back to an assignment on disciplinary innovation and tease out what they thought were the roots of innovation. As each team shared, discussion ensued with one of the faculty members would taking notes on the board resulting in a general understanding built up over the period of the whole exercise. By the time we completed, everyone in the classroom had arrived, together, to a common list for the roots of innovation. It should be noted that while this course was taught twice by the same faculty, the list each year was similar but slightly different. This flexibility in creating common knowledge gave the students ownership of the course and increased their investment while not detracting from the value of their learning. This exercise took 15 to 20 minutes.

We then had a visit from a professor in studio art, Joe Meiser for about 30 minutes. Given that a large number of the students in the class come from professional disciplines (engineering & management) we purposely wanted to expose them to a different discipline's methods for ideation. Professor Meiser presented how artists explore their environment and other artistic exhibits to find inspiration for artistic ideas. He then described various methods that he uses to capture and compile his thoughts, from mind maps to notes in his Moleskine notebook to browsing through a vast personal collection of images on his computer to simply being hyper-aware of the physical world around him. He collects all this disparate information and then uses it to inspire sketches of potential future sculptures. Exposing the students to this type of ideation process was both scary and enlightening. Many were inspired and some just weren't sure what to do with the information they had seen; they were given clearer context once we moved into the *demonstrate* phase of the course.

After Professor Meiser answered many of their questions, the faculty lectured on the value of ideation, using this time to draw out from the students their perspectives. Then, the discussion moved to more traditional means of ideation through brainstorming methods. A list of rules was established and the reasons for each rule. Several methods were introduced (ie. Slip Method, 6-3-5, C-sketch, Morph matrix) along with examples of each and a critical analysis of the pros and cons of each method.

While much of this class was spent on learning tools, the goal of that particular class was really to further the students' definition of innovation. This was accomplished through ideating what was NOT innovation; for us to determine what *wasn't* innovation would help us better define what *was* innovation. In essence we were exploring the white space of a cameo to gain a further understanding of the portrait captured within. The students were asked to break into groups of 4 or 5, preferably interdisciplinary and with people with whom they had not yet worked. Each group selected a brainstorming method from those that had just been introduced and used it to generate ideas. Each group presented their list that they had culled down to 10. Because many overlapped, this helped to build our common understanding of NOT innovation, which in turn helped to build our shared definition of innovation. Students were then assigned to work in pairs for the next homework assignment to research an example of NOT innovation for the next class period. They had to prepare a presentation on this using the Roam method from the first day of class.

*Segment 2: Recognize*

Once a working definition of innovation had been established, we spent the next three weeks (six sessions) exploring which characteristics of individuals or environments help to facilitate, or are even necessary for, innovation. This gave us an opportunity to challenge the students, both mentally and physically, to push beyond their expectations of how learning happens, what they are capable of, and what they need to be successful innovators. The topics we focused on were: failure, risk, creativity, resources, collaboration, and communication. We were able to be quite creative in how we communicated the importance of these topics, further driving them home. For example, to explore the concept of failing forward the students were challenged to hold a textbook 18" above a tabletop using just 2 sheets of printer paper and ½-inch of Scotch tape. Failure was abundant and surprisingly more with the engineering students! John Bravman, the Bucknell University president, spoke about the value of creativity in research and in administration. Roger Rothman, a professor of art history, spoke about collaboration among historical artist communities, which was supported by a visit to the school's theatre department to hear how the various roles within a theatre company work together to create a successful production, presented by Paula Davis, Anjalee Hutchinson, Heath Hansum, and Mark Hutchinson. We visited an improvisational free-flowing jazz session, guided by Phil Haynes from the Music department, to understand the value of communication, teambuilding, and team member roles. While there was a specific goal for each of these sessions, many of the topics wove together throughout the three weeks to provide the students with a rich understanding of an environment that facilitates innovation. This part of the course culminated in a visit from Peter Vigeant of ESI Designs, an industry professional who specializes in innovative interactive games and exhibits. Hearing the testimony of an expert that practices innovation daily and experiencing his games firsthand, fully solidified within the class their need to recognize the right people and environment for innovation, and to see how they can be those people and create that environment.

Figure 2: Students Work on the Failure Exercise

The first assignment in the *recognize* segment had the students individually review the past assignments and describe the mediums of innovation that were employed. They also had to identify the types of people who were involved in the innovations. The second assignment focused on persistence through failure. Students worked with a new partner outside of their discipline on the paper support exercise from class, except the goal was to use the least amount of paper and tape in competition with the other teams. The third assignment was to explore available software for mind-mapping ideas. They had to use the software to describe the functionality, pros and cons. For the fourth assignment, students had to write a reflection paper on an in-class exercise where they formally assessed characteristics of themselves and of another student. The fifth assignment was to prepare a six minute, stand-alone communication about an innovation on campus. This was an assignment over three sessions because it was intended to be challenging. We schedule several guest lectures for the class sessions. The intent for this assignment was to stress the importance of communication in realizing an innovation. It reinforced the segment on defining innovation because they had to explain to people outside of class what they meant by innovation and then communicate the example back to the class. The communication had to incorporate Who, What, Where, When, How, and Why. These communications were really impressive. We had the students assess each of the communications with critical feedback. The students then wrote a reflection paper on their assignment and peer assessment. All of the students demonstrated proficiency in recognizing the role of the person and the environment in innovation. They also learned how difficult it is to effectively communicate all of this in six minutes. What was equally impressive was the quality and detail of the peer assessment. The students recognized the value of critical feedback on their work. They wanted it, so they also provided it.

At the mid-semester we met with each student individually to discuss our assessment of their performance in the class. Utilizing models asserted by Pellegrino[22], we wanted to determine whether they not only understood the individual facts presented in the class but also understood

the connections between the various concepts and could further "transfer these concepts to other situations. The mid-semester assessment addressed how well we thought they were progressing in this direction with the hope that the final project would confirm our learning intentions. We told them what we thought they were doing well and where they could improve. We then asked them for response to our assessment. And because turn-around is fair play, we asked them to assess us. The students responded to this discussion thoughtfully and openly. They were also very forthright in their assessment of us and the class with both positive and negative comments. They followed up on our meeting with a reflection paper.

*Segment 3: Demonstrate*

The rest of the class, which constituted more than half of it, was spent learning some basic tools to help facilitate innovation and how to apply these concepts to create an innovation for a particularly broad topic: *Children at Play*. After introducing the project, but before the students were ready to tackle their own project, we walked them through topics and methods that would be useful for their own innovating. It should be noted that the students were required to pick their own interdisciplinary teams, minimizing the number of people in each team from the same discipline. Starting with opportunity recognition and selection, we introduced concepts like Social, Economic, and Technology (SET) Factors and Product Opportunity Gap from Cagan & Vogel's *Creating Breakthrough Products*[26]. We introduced the concepts of scoping, knowing how much of a project to commit to given the resources, and how to measure success. We then visited Dave Evans's observational research lab for child psychology while he spoke with us about how observational research works and the pros and cons of various methods. The students were able to apply their learning in an out-of-class assignment at local playgrounds. The class was also visited by Ian Proud, a topical expert in *Children at Play* from Playworld Systems, an international playground manufacturer, who provided key insights from his many years of experience.

Before we continued, the student teams presented their initial innovation concepts to the class. This started the final project phase by which we could assess how well the students learned the material from the class, made necessary connections between the concepts and facts, and were able to create a construct with which they could then apply to a novel innovation[22]. Additionally, this provided a wonderful opportunity for the students to provide constructive criticism, another one of our implicit goals that had been exercised at least once per week throughout the semester. At this point, all of the students were quite comfortable with providing and receiving feedback on their ideas and presentations, a significant change from the first day of class.

The last six weeks of class were spent with the students primarily working on proving their innovation while we continued to visit topics relevant to their success. We spent time on how to evaluate concepts and make decisions, utilizing a variety of tools such as post-it voting and decision matrices. One of our favorite learning activities was used to communicate the importance of assessing your resources and the value of iterating. We had the students break into teams or three or four, interdisciplinary as always, and go on a photo scavenger hunt. They were given a list of locations and point values for their taking a photo of their team at that location. The list was constructed so that sites located further away had larger point values. This forced the team to pick a path that enabled them to maximize the number of points they could get within the allotted time of one hour. Upon completion, each team had to revisit their chosen path and

suggest what they could've done differently to better utilize their resources, demonstrating the value of iteration. In another class we were joined by Dave Robertson, an expert in Lego toys, who presented a case that challenged our perceptions of innovation and how to approach it. Finally, the last topic was on how to successfully implement an innovation, the visit from Sue Ellen Henry and the Poolpass Project described in the introduction of this paper.

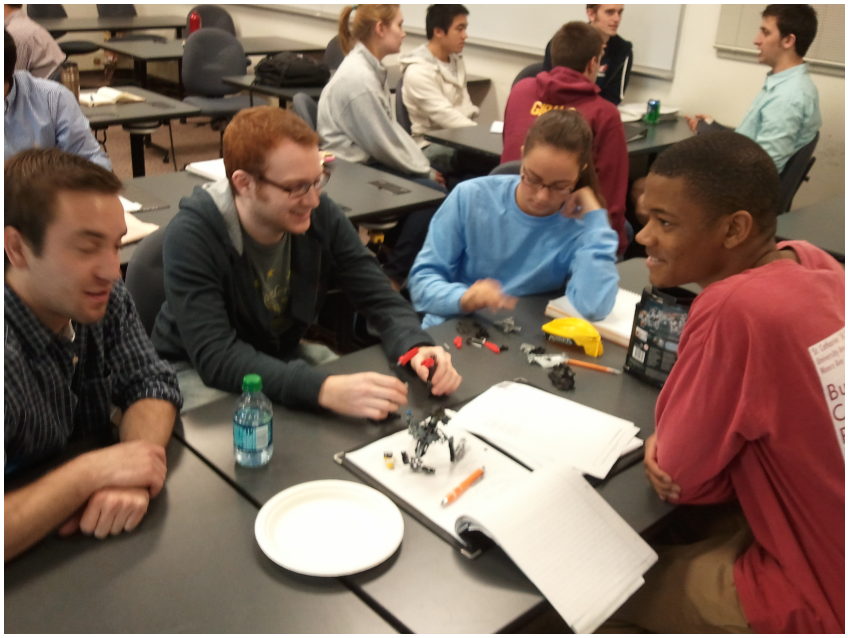

Figure 3: Students Work on an Exercise During the Lego Lecture

For the *demonstrate* segment students were working on their projects, but we also added a few additional assignments. We made these relevant for their projects. For example, one assignment was to be "innovation anthropologists" and observe children at play. This assignment preceded the guest lecture from Ian Proud, lead designer at Playworld Systems. Another assignment required them to pitch the idea for their project to the class. Students provided both verbal and written feedback. It was impressive that both semesters the students provided mature and critical feedback to their peers. The teams also prepared two formal status presentations on their projects to the class. Again, they received verbal and written peer feedback. Each time the team prepared a reflection paper on the feedback.

Projects

While exploring innovation can surely provide a unique educational experience, we felt that an application of the concepts was needed to place the course material in context and provide reinforcement. The primary objective of the final project was for the students, in interdisciplinary teams of 3 to 5, to apply what they had learned throughout the semester but within a very broad theme of "Children at Play". This theme was intentionally left broad and ambiguous because we didn't want to overly constrain the students. As a class we determined what were the measurable criteria for the projects, based upon what we had learned thus far. The first time we taught the class, we determined that for a project to be an innovation it must be considered across the

following criteria: novelty, interesting, utility, feasible, related to theme, user friendly, value, elegant, cost, and impact. While the students took ownership by choosing these final criteria, they were gently steered by the faculty throughout the semester to recognize these as important.

Given the diversity of students, the unique make-up of the teams, and the vagueness of the theme, there was a wonderful variety of projects. One was an interactive merry-go-round for a playground in which children would have to move levers to add or subtract musical sounds while the merry-go-round turned and produced music. Another was a smartphone app that enabled traveling families to quickly locate a place to stop and play given constraints of time, age of children, money, and distance. Yet another was an interactive pool game that worked much like a traditional board game but leveraged all the excitement of playing outside in the pool. All of the projects were unique and most did a great job of integrating all the concepts and aspects of the course.

Figure 4: Secret Seeds Project (ME, Biomed, Education)

Figure 4: Merry-Go-Sound Project (ME, College Major, Psychology-Marketing)


Figure 6: ApPlay Project (Art, ME, Management, Philosophy)


Figure 7: YouZoo Project (ME, Management, Biomed, Art History)

Figure 8: Pirate's Plunge Project (ME/ Management, College Major, BME, Management )

The students had seven weeks to work on their project. The course concluded with a project exposition open to the campus. Each of the teams set up their communication material, from poster boards, to physical prototypes, to videos, to interactive demonstrations. Invitations had been sent out weeks earlier inviting all the guests of the course, friends, and other faculty. The expo was open for two hours during which visitors wandered in, stopped at the various booths, and discussed their observations over snacks. The final project was assessed by the student peers and by outside judges. As instructors, we did not assess their projects because we wanted to be viewed in a supporting role like Peter Gunn on the show *Project Runway*. The students created their own criteria for assessment as a class and agreed upon the resulting assessment instrument. We compiled the results for each category for both semesters we taught the course. Ratings were on a ten-point scale.

Table 1: Semester 1 Tabulated Project Assessment

| | AP PLAY | XBOX FRIENDS | SECRET SEEDS | HOVER CRAFT | MERRY GO SOUND |
|---|---|---|---|---|---|
| Novelty | 6.7 | 7.5 | 8.8 | 7.9 | 8.1 |
| Interesting | 7.8 | 8.2 | 9.1 | 8.4 | 7.6 |
| Utility | 8.8 | 8.4 | 9.0 | 6.4 | 7.6 |
| Feasible | 8.8 | 7.2 | 9.6 | 5.8 | 7.4 |
| Related to theme | 9.2 | 8.5 | 9.4 | 9.3 | 9.1 |
| User friendly | 9.4 | 8.3 | 9.4 | 6.8 | 8.4 |
| Value | 8.1 | 8.8 | 8.9 | 7.0 | 6.4 |
| Elegant | 8.9 | 7.9 | 8.9 | 7.0 | 6.3 |
| Cost | 8.8 | 6.8 | 8.8 | 5.9 | 5.8 |
| Impact | 7.5 | 9.2 | 8.4 | 6.4 | 5.5 |
| Communication | 9.2 | 8.8 | 9.4 | 8.4 | 8.6 |
| Professionalism | 8.7 | 9.6 | 9.6 | 7.7 | 8.5 |
| WOW factor | 7.7 | 7.7 | 8.2 | 7.8 | 6.9 |
| Comprehensive | 9.0 | 8.9 | 9.2 | 7.6 | 8.3 |
| Knowledgeable | 9.1 | 9.4 | 9.4 | 8.2 | 8.7 |
| Appropriate Media | 8.8 | 8.9 | 9.5 | 7.5 | 8.3 |

Table 2: Semester 2 Tabulated Project Assessment

| | Field Day | ImagiBox | Pirates Plunge | YouZoo |
|---|---|---|---|---|
| Novelty | 8.1 | 8.9 | 8.4 | 8.2 |
| Feasible | 8.9 | 8.9 | 8.4 | 7.5 |
| User Friendly | 8.7 | 8.8 | 8.4 | 8.7 |
| Relevance to theme | 8.7 | 9.2 | 9.3 | 9.2 |
| Impact on Goals | 8.5 | 8.7 | 8.6 | 8.6 |
| Engaging | 8.4 | 9.0 | 8.7 | 8.7 |
| Clarity | 8.4 | 8.8 | 8.4 | 8.6 |
| Scope | 8.5 | 9.0 | 8.5 | 8.2 |
| Visuals | 7.9 | 9.4 | 9.2 | 8.9 |
| Delivery | 8.3 | 9.1 | 8.5 | 8.9 |
| Wow Factor | 7.6 | 9.0 | 8.5 | 8.2 |

Review of the scores indicate several insights. One insight is that the scores are not all high. The evaluations were very critical. Student peer evaluations were more critical than the guest judges. In the first year, the students included cost as a criteria. Two of the projects rated very poorly. In the second year, the students focused more on appropriateness of scope and eliminated the cost criteria. We also noted the importance of effective and appropriate communication of their project for influencing the ratings. Teams with strong visual aids and engaging pitches performed better.

Students completed the semester by providing a stand-alone communication of their project. Instructions were purposely vague, but the students had become comfortable with this environment. Resulting communications varied from self-starting slide shows in Powerpoint or Prezi to complete videos.

Student feedback for the course was overwhelmingly positive. Using the IDEA form for teaching effectiveness[27], the course rated in the highest 10% of classes for each of the five relevant objectives: (1)Learning to apply course material (to improve thinking, problem solving, and decisions), (2)Acquiring skills in working with others as a member of a team, (3)Gaining a broader understanding and appreciation of intellectual/cultural activity (music, science, literature, etc), (4)Learning how to find and use resources for answering questions or solving problems, (5)Learning to analyze and critically evaluate ideas, arguments and points of view. The course and instruction was rated as excellent with a 4.8 on the 5 point scale. Students rated the effort for the course as 4.8 on a 5 point scale relating to the effort in other courses.

There were many positive comments on the course. Among them:
"Awesome course. I know many people who want to take it and it has been one of the most memorable classes I have ever taken."
"I thought that it was so incredible to have so many guest lectures – professor and visitors."
"Working in interdisciplinary groups! [was one of the most helpful elements of the course]"
"Really prepared me for the real world."
"Amazing class. I can't wait to apply what I have learned."

There were two common themes for improvement. One was to start the project earlier. The other was the challenge they had without grades on each assignment.

Lessons Learned

*Push for excellence* – In the first iteration of this course we made a point to serve only as consultants for the final student project. This gave us the opportunity of providing open and honest feedback while removing any concern that the students might have regarding the assessment of their projects. Unfortunately, we had one student team that continually neglected to follow our suggestions and often procrastinated in their implementation of their project. This slowly snowballed over 6 weeks until they finished with a mediocre project, probably not an innovation by our class's definition. Most likely this could have been curtailed if at some point sooner in the project the faculty had explicitly removed some of their freedom to prevent them from driving over a cliff. In the end, the team was quite happy with their project even though many of the guests and judges at the expo were disappointed.

*Start project earlier* – One piece of feedback that was given in the first iteration of the class is that there simply wasn't enough time to dedicate to the project and that if we started it earlier they would've had more time to create their innovation. The faculty, fully recognizing that it's virtually impossible to prove an innovation in a 16 week semester, still agreed that starting earlier could have its benefits. That said, starting too early could also be counter productive in that the students wouldn't have learned enough to move forward proactively and would end up having to redo much of their early work. In the end, we kept the project announcement at the

same time, the beginning of the 6th week, but moved up the deadline for the project decision and provided the students with more in-class work days. This seemed to help considerably but still ended up being a considerable time crunch towards the end of the project. This is probably best dealt with through frank discussions about scoping and spending some time in the first part of the semester recognizing how many years were required for our innovation examples.

*Recruiting is necessary* – We found in the first iteration of the course that faculty from all over the campus were so excited about the class that they helped us recruit students from a wide variety of disciplines. The second year, we had some challenges. Two of our key recruiters were on leave and the time we chose for the course conflicted with required classes in some of the non-professional disciplines. Since the value of this course is in the diversity of the students, we realized that to build an interdisciplinary class we need to be aware of potential conflicts and also need to start recruiting early with assistance from faculty throughout the university, many of which end up visiting the course as guests.

*Workload expectations varied considerably by discipline* – This was a rigorous class with readings and deliverable assignments for almost every meeting. Students reported that they were spending much more time on this class than others. The engineering students were more accustomed to the regularity and time demand of assignments, but had to adjust to the continual expectation for formal and informal reflection.

*Students crave rubrics and grades* – It is clear that students are programmed to respond to established rubrics to perform for grades. We purposefully made some assignments vague to get the students to formulate their own ideas about what is important. Although they received a lot of critical feedback from us and their peers, they craved a letter grade. Many of the students in the class were second semester seniors so they begrudgingly adjusted to the environment. We emphasized that they would soon transition to a work environment where formal reviews would likely only occur annually, so they needed to be self-critical and interpret comments. We considered changing to grades for the second year, but decided to keep the approach. However, we used more traditional language in our feedback. For example, “Good job”, “Excellent work”, or “Need to improve”.

*Faculty and outside speakers loved being involved* – We were impressed with the enthusiastic response from faculty and others willing to share their time and knowledge. The quality of their “lectures” was outstanding. We held several meetings with the guests to plan out their “lectures”. These meetings led to broader discussions about innovation and formed closer interdisciplinary relationships. The faculty then recognized that we have more in common then we had before realized. These relationships have led to other collaborations with guest lectures occurring in a number of different courses. For example, one of us has given a guest lecture on kinematics and mechanisms to the sculpture class assigned to create mechanistic art. And Joe Meiser, professor in studio art, is team teaching a class for the MIDE program. Additionally, we have faculty now working together on scholarship writing papers and preparing grant proposals.

*Language is important* – We learned that different disciplines use different language to describe similar things. Yet there are subtle differences that can be challenging. This aspect is something that we explored throughout the course.

## Future Plans

Our first hope is to make this a course that continues to be available each year and that students continue to enroll in despite it being an elective and a permissions only course. Since so much of the course content is really handled by guests and is dynamic within the structure of the whole semester, our hope is to also make the teaching faculty more dynamic. Bucknell has a unique environment in which faculty can easily co-teach classes that cut across disciplines. In fact, these types of courses are not only encouraged but are required within the new curriculum for the College of Arts and Sciences. Additionally, Bucknell has a group of over 60 faculty and staff that are anxious to support each other in interdisciplinary innovation. We think this creates a unique opportunity where this class could cycle through faculty, growing and changing through the years. Because the class is always team taught, there could always be a faculty member who has taught the course previously paired a new faculty member. In each case, faculty would only have to commit to 2 years though they could continue to return to class as one of the many guests. More importantly, the course would stay dynamic and engaging, changing regularly around the fixed course objectives and goals. This type of living, breathing course would continue to meet the current needs of the students while providing a fresh and engaging perspective each year.

The course counts as a technical elective in Mechanical Engineering and satisfies a requirement for students in the MIDE program. It also satisfied students' UNIV requirement. It could count as a technical elective in other engineering departments if their program allowed for technical electives outside of their department (not all do). These were the easiest designations to establish because the instructors came from those departments. We have learned that there would be added benefit to the liberal arts students to get the course to count for one of their requirements. We plan to work with the university curriculum committee to get those approvals.

## Conclusions

In this paper we have described a new course that engages students and faculty across the disciplines of engineering, management, arts and sciences. The course has students work together on interdisciplinary teams on varying types of assignments to build tolerance for functioning outside of their comfort zone. We help students to understand that innovation does not involve just creativity, but requires a broad range of knowledge, skills and character traits. We emphasized the breadth of knowledge that is required to realize an innovation and a focus on the value proposition. We helped them develop the necessary skills such as communication and teamwork. We promoted the importance of persistence through failure and regular critical reflection. We helped prepare the students for success in their careers and personal lives so that they can make an Impact.

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