Using a Cross-Disciplinary Course to Enhance Creativity, Collaboration, and Communication Skills: Signals, Systems and Music

Many universities integrate general education with program-focused courses (Hart Research Associates, 2009). There have been some attempts to connect engineering and the liberal arts and sciences (Wunsch, 1998; Kuc, 2001). A new trend, which began during the past decade, brings together students from the liberal arts, sciences and engineering to learn together rather than attempt to teach them *about* one another's disciplines (Klein, 2007, Klein, et al., 2009). The concept that we present herein is an exemplar for exposing conceptual commonalities across disciplines. Music is an organization of audio signals produced by systems. When musicians consider a piece, they look at the elements of music—rhythm, melody, harmony and timbre. When engineers consider a signal, they talk about frequency spectrum, amplitude distribution, energy content, and information. Organizational considerations of melody, harmony and rhythm are not entirely different from frequency, amplitude and time; they simply constitute a variance of perspective. This project promotes interaction between music and engineering to provide students with an educational experience that may stimulate learning. Data were collected over two semesters piloting the course. Qualitative methodology included pre and post interviews, observation field notes, and group discussions.

The Course

Music, Signals & Systems was the chosen title of a course that addressed the topics of music composition and electronic signal analysis and generation. This collaboration included the Electrical and Computer Engineering and the Music Programs at Kansas State University and Rowan University. For the electrical engineering students it was a general-education elective. For the music students, the course was an elective for all except composition majors, for whom each semester was a required course.

The course had neither math nor music prerequisites and treated the topics from a holistic perspective of both systems engineering and music composition. Creativity was an important aspect of this course. A principal intent was to help students recognize that they are creative beings and to provide experiences that exemplify creativity in its various forms. Through creative music composition from an engineering-systems point of view, students were exposed to concepts fundamental to both music and engineering, emphasizing the interconnectedness of the disciplines, with a learning goal of (re)awakening the students' creativity (see Figure 1: Learning goals).

Course Sequence

The students were provided creative opportunities—small projects that led to a major project, near the end of each semester, consisting of a musical composition realized by a partnership of a music student and one or two engineering students. The interests, backgrounds, and strengths of each partner, combined with the ability and willingness to communicate well

with each other during the creative process, provided a foundation for important student learning beyond the content (See Figure 2: Course content).

First Impressions

All the engineers expressed excitement about exploring their: "creative side, which is not so well developed. We don't get as much of a chance to explore this area" (EE7). They described training in the field of engineering as including limited coursework that makes reference to the development of creative abilities: "There aren't a lot that even allude to it. It is very subtle if it is included in the curriculum" (EE1&EE2).

> Creativity in engineering is kind of a standing joke. I know they want us to possess creativity, but thinking outside of the box is not what we do. We are taught to think in a linear way, to find the most efficient and economical way to move from one point to another, whereas the type of creativity involved in music is starting from scratch and sometimes throwing out the established way to create a new way. (EE5)

Following the first class period, the engineers: "recognized the intense passion that each group had for their discipline" (EE1) and "the strong work ethic associated with successful achievement for each group" (EE3). Similar observations were noted both semesters by each of the groups.

Creativity

The experience of interacting with the creative process from within another's framework was precisely what the engineers had described as a perceived deficiency for their future success. One engineer described this need:

> I can get straight A's in my classes without using a lot of creativity. They want to make sure we can follow a process. But in order to be a good engineer, we will eventually have to break from the established lines of thought. I have observed the musicians compose beyond rules of an established system. That is a new thought for me. (EE4)

The final projects for this course were unique in every way. Although this was not surprising to the musicians, this was astonishing to the engineers: "I am amazed that no composition remotely resembled another's project. In many engineering classes, there are only so many ways that projects can be done, so in the end, many usually have identical results" (EE6). The open-ended process without a specified endpoint was acceptable for the musicians but challenging to the engineers. The engineers expressed awareness that this process required an alternative form of creativity:

> It would have been easier if we had been given a checklist of things for each assignment, but without these parameters, we were forced to make decisions on our own. It forced us to be creative in ways that may not have been achieved if we had to meet certain criteria. (EE6)

Student learning associated with this open-ended process was exposed during the interviews near the end of the course:

> I've always believed that everything that is important to learn is assigned and has a point value. Now I consider projects with more of a purpose than gaining points. I should be thinking, *what am I trying to learn from this*, and *if I wasn't assigned this project, how would I approach this problem.* This is very different than what I have experienced in my engineering background. I will now look at engineering projects with more of a goal in mind rather than just to get it done. (EE5)

Prior to the course, the engineers expressed efficiency of problem-solving as a primary attribute of engineering. Learning the creative process through music composition enabled an alternate conception:

> I learned that the creative process takes time. We talk in engineering about a flash point, when things just come together. But I never considered how much time it would take. I definitely learned that creativity does not happen in a single try. It takes doing one thing, stepping back to consider it, revising or adding something, then stepping back again. You get out what you put in when it comes to creativity. I have a lot to learn before I will be useful with this type of thinking. Experiencing it through music composition provided an interesting take on the creative process. (EE5)

Learning to Collaborate and Communicate Effectively

Both disciplines have a focused curriculum that requires an abundance of time working with disciplinary colleagues. But, although working with others outside their disciplinary coursework is an important contribution to future career success, they did not recognize having previously experienced this:

> I am used to working with engineers and even share an apartment with engineers, so working with someone whose background is different has been a very good experience. There is a bad stereotype that engineers don't communicate well, and it's partly true. We get so bogged down in technical classes and advanced knowledge of our field that we find it difficult to step back and communicate ideas with others on an appropriate level. I have been told many times that, as an engineer, I will need to be able to communicate my ideas. Learning about other disciplines is important so I can talk about things without sounding like an idiot. (EE3)

Both the engineers and the musicians described how communication was enhanced through working as a team: "Working with another person on the project was a way to get different ideas, like: two heads are better than one. But it also allowed for each of us to go explore independent directions" (EE7).

Most described that they were not used to collaborating. Independent decision-making had been the norm:

> It was a little difficult for me because I like to have control, but his ideas were better than mine. As far as the compositional aspect, he has a level of knowledge and skill that I can't match. I had to learn to trust him. It forced me to let go a bit. (EE4)

The students described ways in which they maximized each other's knowledge, talents, and

capabilities to reach personal or common goals in the creative process. When one needed guidance or assistance, the other contributed in ways that facilitated a partnership in the creative development of the composition:

> It was interesting how we went at the final composition. We came to the project with different ideas about how to go about things and collaborated with the types of sound we wanted to use. He had some ideas of how things should sound, and I tried to emulate it on the keyboard until it represented what he had in mind. (M1)

The engineer explained the same collaboration from his own perspective:

> The creative process was interesting. My musician partner would find a couple of chords and create something that sounded cool. I found it difficult to come up with something original. But as we worked together, I was surprised: he would bounce his ideas off of me. I might say, *we need to add some higher didily sounds*. I had to use some weird words to explain what I was thinking because I didn't know the musical vocabulary. It sounded funny to hear us talk, but he knew what I meant. (EE3)

This exemplifies an interaction of alternate conceptions that generated new ideas not attainable individually or through like-minded interaction. Many others described similar learning attained from the cross-disciplinary collaborations: "I think the most important thing I got out of the course is working with another person because, as an engineer, we will mostly work with someone that knows about one side of things" (EE8).

> A very important thing I learned was working with someone that is not of like mind. I came to the project with a checklist of each component, and my partner would say we don't necessarily have to use each component if we are able to generate the sound using a few. It was a different approach to getting the same thing done. I think it is important to learn that there may be different ways to solve a problem. In the engineering world, we are taught there is a specific way to solve a problem, but realizing that there are multiple ways of reaching the end product, although it may alter the end product in some way, may be an important learning from this class. (EE6)

Both of these students confirmed new understandings in problem solving.

Enhanced Learning

This course with two diverse groups "pushed everyone in areas outside of their field's comfort zone. Cross-disciplinary education is challenging because it develops an open mind" (M2). When disciplinary content was difficult to understand, the situation enabled students to "rely on each other. This created camaraderie not inherent in a tightly structured, single-discipline course." The varied processes of problem solving experienced from each discipline developed an awareness of possibilities:

> What I learned was to take a wider view of a problem. I usually follow set directions, but as the project evolved, my consideration of how to solve a problem was expanded. I guess working with others to get ideas is useful. (EE4)

Conclusions

Students discovered and experienced: (a) pursuit of creative alternatives beyond a discipline's normal framework; (b) acceptance of multiple/alternative outcomes as a result of creative problem-solving; (c) effective communication with consideration of another's beliefs, understandings, and intentions; and (d) trust in collaboration as a means of creative inspiration. Interdisciplinary coursework was an important means in developing essential engineering skills.

References

Klein, J., Traver, C., Raucci, S., & Jones, S. (2009). Special session - inventive courses: Blending engineering and the liberal arts, *Frontiers in Education Conference, 2009. FIE '09. 39th IEEE*, 1-2.

Klein, J. & Balmer, R. (2007) Engineering, liberal arts, and technological literacy in higher education. *Technology and Society Magazine, IEEE ,26*(4) 23-28.

Kuc, R. (2001). Teaching the nonscience major: EE101-The digital information age. *IEEE Transactions on Education, 44*(2), 158-164.

Hart Research Associates (2009). Trends and emerging practices in general education, Report by Hart research associates, Washington D.C. found at: http://www.aacu.org/membership/documents/2009MemberSurvey_Part2.pdf

Wunsch, A. (1998). Electrical engineering for the liberal arts: radio and its history. *IEEE Transactions on Education, 41*(4), 320-324.

Acknowledgments

The support of the National Science Foundation (Award No. 1044734) is gratefully acknowledged. The opinions expressed herein are those of the authors and do not represent NSF positions or policies. We would also like to thank the many students who have participated in our *Signals, Systems and Music* courses and contributed their ideas to improving various components of the courses.

Figure 1: Student Learning Outcomes

Upon completion of the course, the student will have the knowledge and skills to:

a. describe the historical relationship of the electronic manipulation of sounds in the creation of music, and the relevance of that relationship for contemporary creativity.
b. demonstrate an understanding of the aspects of the basic physics of sound as it relates to what is perceived as musical sound.
c. understand the electronic generation of musical sounds and how to duplicate/transform “traditional” musical sounds as well as how to create “new” electronic sounds.
d. creatively use a variety of sound-modification devices and techniques in the creation and realization of short musical pieces.
e. exhibit a conceptual understanding of how the elements of music (rhythm, melody, harmony and timbre) relate to elements of engineering (e.g., frequency spectrum, amplitude distribution, energy content, and information) and how they relate to the creative organization that occurs within a musical composition and engineering constructs.
f. organize traditional, manipulated, and created sounds into a musical composition utilizing the electronic musical sounds that clearly integrates the musical and engineering elements in a purposefully creative and aesthetic arrangement.
g. investigate the interplay between their musical and technological imaginations as well as study the fundamental aesthetics of music and signal processing.

Figure 2: Course Content

Semester 1

Historical Background

Instruments (sounds, timbres)
Creative composers and stylistic variety (immersion experience in earlier compositions, combinations of sounds)
Technological development and their integration (engineering connections)

Analog Modular Components

Wave modification
Creative, musical use (small projects)

Compositional Project

ProTools software interface project
    Filtering
    Duplication, overlap, organizing sounds

Semester 2

Historical Foundations and Current Technology

Hardware-based synthesis
Software-based synthesis
Current Varieties of Synthesis
    Analog, FM, digital, sampling, processing

Digital Synthesis

Learn to use digital-synthesis tool
    What is it, electronically (from both the engineer's and the musician's viewpoints)?
Receive instruction in cooperative and collaborative processes
    Developing a creative relationship
    Psychological relational models of collaboration
    Small collaborative experiences through learning the technology

Team Projects

Create a musical environment
Create a new musical experience for a traditional musical form (or composition)
Create an educational tool (app) that enables a group of people (socially limited, disabled, culturally deprived populations) to communicate or experience emotion or feeling through music
Create a musical composition with an audience in mind