Summary of Activity and Students' Responses for Kansas State University's Versions of the "Signals, Systems and Music" Course

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The following information is gathered for use in the final report to the National Science Foundation on the project "Music, Signals & Systems: A Multi-Campus, Cross-Disciplinary Course for Inclusive General Education" (NSF Award No. 1044734). The introduction includes introductory matter from the original proposal to NSF.

Music, Signals & Systems: A Multi-Campus, Cross-Disciplinary Course for Inclusive General Education

An area often neglected, or not considered as associated with Electrical Engineering in traditional programs are those courses associated with General Education. Most universities recognize and implement integration between general education and program major courses [1]. All undergraduate courses—including those within the major fields—should offer students numerous opportunities to develop competencies in general-education learning outcomes.

> Students can no longer be expected to learn how to solve problems in a precisely defined area of engineering but need to be prepared to situate these problems into multiple settings. Conceiving engineering as a liberal art indicates that engineering knowledge is required not only for a specialized career path but also increasingly important for active participation in citizenship. This idea challenges universities to rethink fundamental notions of both the liberal arts and engineering. Experimentation with new curricula in these educational areas should be a priority of universities, especially engineering institutions" [2].

There have been some attempts to bridge the gap between educational experiences in engineering and the liberal arts and sciences. One popular version is to provide a course for students, early in their collegiate career, to learn an engineering application that has direct relevance to their lives. This approach has been used at Yale University in the course EE101─*The Digital Information Age*, where students are challenged to explore some of the signal-processing underpinnings of the World Wide Web [3]. At UMass Lowell, Professor Wunsch developed (and still teaches—see [4]) *The History of Radio,* where liberal-arts students are introduced to electrical engineering through a survey of wireless communications [5]. As with EE 101 at Yale, *The History of Radio* is intended to meet a Mathematics and Science general-education requirement for non-science majors; consequently, engineering students do not enroll in these courses because they either don't count toward their requirements or they are restricted to non-science or non-engineering majors. An additional common theme in technical-literacy courses is the effort to allay the discomfort of non-technical people with technology [6], [7]. The pervasiveness of technology has made this somewhat irrelevant since today's population are already familiar with using technology.

A number of efforts have been made to combine engineering with the communication arts: writing and public speaking. A senior-design course at San Diego University [8] and at Rowan University includes a final semester of Senior Engineering Clinic designed as Writing Intensive. Also, at Rowan University, a writing course and a public speaking course have been merged with a technical design lab, providing students with an opportunity to enhance written and oral communication their learning. These general-education opportunities provide a broadening of the engineering curriculum, but include only engineers and focus on traditional engineering concepts [9].

A new trend has begun during the past decade, where attempts are being made to bring together students from the liberal arts, sciences and engineering to learn together rather than attempt to teach them *about* one another's disciplines. At Union College, Dartmouth and the

University of Alabama [10], [11], [12], creative solutions are being developed to Professor Snow's [13] challenge to bridge the "Two Cultures." These learning experiences, however, are primarily clustered in the first and second year of the student's college experience and, by avoiding mathematics and complex reading assignments, provide a "taste" of the trans-disciplinary experience. Fortunately, today even this trend is changing and there are a few who are beginning to insist that deep knowledge can't be split along any cultural dividing line [14]. In particular, Union College in Schenectady, NY, has developed a new curriculum, Converging Technologies, "…for integrating the arts, humanities and science with modern technology and engineering in a way that will enhance student's technological literacy for the 21st century" [15]. Their comprehensive view of the problem of eliminating the artificial separation of knowledge by culture, and their comprehensive view of the solutions, provide inspiration to programs that hope to make substantive changes to engineering, science and liberal-arts education [16].

Credit for this turn toward a more inclusive college curriculum is shared by imaginative teachers, researchers and administrators. As education becomes increasingly multidisciplinary, academe is acknowledging that models for understanding the world—social, physical, and aesthetic—can no longer be isolated. Take, for example, the notion of music as signals produced by systems—the concept that we present herein as an exemplar course for exposing conceptual commonalities across disciplines. When musicians consider a piece, they look at the four elements of music—rhythm, melody, harmony and timbre. When engineers consider a signal, they talk about frequency spectrum, amplitude distribution, energy content, and information. Music is an organization of audio signals. It is important to recognize that the difference between the two perspectives is more than semantic. Organizational considerations of melody, harmony and rhythm are not entirely different from frequency, amplitude and time; they simply constitute a variance of perspective. What this project promotes is a view of knowledge as a continuum among disciplines; an interaction between the disciplinary-specific knowledge of music or engineering that can provide students with an educational experience that may stimulate learning. When students address concepts such as these from a particular perspective, what appears as a conceptual similarity is justified by the student through their own lens of understanding and neglecting other considerations. On the contrary, a cross-disciplinary approach focuses on concepts common between disciplines while exposing their understanding to considerations beyond disciplinary relevance [18]. Integration is more than simply interweaving subject matter. This curricular approach focuses on "elements that might be taught more effectively in relation to each other (rather) than separately" [19]. The perspective of a musician will certainly be different from that of an engineer, but when approached together, the learning will represent knowledge uniquely unattainable purely within either discipline.

General-education courses are intended to provide students with broad understandings that can enhance learning within as well as beyond their field of study, but commonly and unfortunately reinforce that certain courses are about topics outside their major. A strong educational impact is often recognized when students appreciate interconnectedness of the various aspects from disciplines. As a new concept of a general-education experience that transcends traditional disciplines, this project examined a model for a general-education course that is inclusive of general-education outcomes and supports foundational development in program curricula. This concept expands traditional general education's focus of extradisciplinary courses to expose students to novel points of view, including immersion in interdependent, cross-disciplinary knowledge, and promote curiosity, creativity and innovation.

Table 1: Typical General Education Goals

A brief survey of the rationale for General Education used by universities across the US yields a number of common themes. Table 1 gives some quotes from the General Education program websites at a few universities and colleges. The quotes serve to illustrate what faculty believe constitutes a set of skills that characterize an educated person—and that are somehow missing if the student completes only his or her major courses!	
THINK	
improve critical and analytical thinking http://courses.illinois.edu/cis/gened/	University of Illinois–Urbana Champaign
sharpen critical-thinking, problem-solving, and communication skills http://www.wright.edu/gened/	Wright State University
make critical judgments in a logical and rational manner http://bulletins.psu.edu/bulletins/bluebook/general_education.cfm	Penn State University
BE AWARE	
encourage breadth and flexibility of perspective http://bulletins.psu.edu/bulletins/bluebook/general_education.cfm	Penn State University
broaden their intellectual perspective http://www.registrar.ucla.edu/GE/>	UCLA
appreciate the achievements of civilization, understand the tensions within it, and contribute to resolving them http://studentrecords.umaine.edu/academics/genedreq.htm>	University of Maine
broadening awareness of the world in which we live http://www.montgomerycollege.edu/curricula/gep.htm>	Montgomery College MD
APPRECIATE	
learn about the aesthetic, ethical, moral, social, and cultural dimensions of human experience http://www.wright.edu/gened/	Wright State University
expand their historical, aesthetic, cultural, literary, scientific, and philosophical perspectives http://courses.illinois.edu/cis/gened/	University of Illinois–Urbana Champaign
comprehend the role of aesthetic and creative activities expressing both imagination and experience http://bulletins.psu.edu/bulletins/bluebook/general_education.cfm	Penn State University
COMMUNICATE	
seeks to develop critical literacy; respect for others; creative expression; effective communication, both written and oral	Montgomery College MD

This project exposed consideration for how knowledge is portrayed to students and how the university can provide a foundation for learning that supports student needs into the future.

The Course

The course—entitled *Music, Signals Systems* at Rowan University, and *Signals, Systems and Music* at Kansas State University—addresses the topics of electronic-signal analysis and generation, systems-oriented approaches to creative acts, and music composition. The effort was a collaboration among the Electrical and Computer Engineering Departments and the Music Departments of both Rowan University and Kansas State University. The initial target audience was first-year electrical and computer engineering majors and undergraduate music majors. At Kansas State University, *Signals, Systems and Music* was offered during a fall semester and a following spring semester. For the electrical engineering students it was a general-education elective. For the music student, the course was an elective for all but composition majors for whom each semester was a required course. For the music students, the course was offered in the fall under the title *Technology of the Electronic Music Studio* and in the spring semester under *Digital Sound Synthesis*.

The course had neither math nor music prerequisites and treated the topics from a holistic perspective of both systems engineering and music composition. A significant experience of the Signals, Systems and Music course was that of creativity. The students were reminded that creativity is important in whatever disciplinary path they choose. Part of this course was to help them recognize that they are creative beings; to provide experience to develop creativity; and to exemplify that creativity, in its various forms, is founded upon understandings of fundamental elements within a discipline. 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.

At Kansas State University the electrical engineering lab was the place of choice for the fall-semester version of the course because of the availability of EE hardware and space for the music technology. We felt that one evening per week of seat time with additional work outside of class on the equipment would provide sufficient experience to fulfill the learning expectations.

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.

After the first semester, we realized that scheduling student creative work into one space was problematic: "The most challenging aspect we had to deal with was scheduling. Both the musicians and the engineers arguably have two of the busiest disciplines on campus" (M1).

> I was surprised how many hours musicians spend beyond the normal school day. Things like concerts and rehearsals are almost constant. Balancing my schedule with someone that has a drastically different schedule than you was a learning experience. (EE1)

Another problem encountered was students "feeling self-conscious while working in the lab when there were other engineers from other courses in the room working on projects. I thought I was bothering them. I made sure, that before I started doing anything, to apologize for bothering them" (M2). For the second semester we moved the classroom from the electrical engineering Communications Circuits Design Lab to the Music Technology Lab and used individual software that would allow students to work together or individually from any computer in and beyond the lab. These changes removed the restrictive environment experienced during the first semester.

The educational context in which creativity was to be nurtured became an important consideration of the course. Many students were familiar with expectations of completing assignments as directed and not as proficient when allowed the autonomy of choosing the process and structure of their assignments. Every engineer 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" (EE2). They described that training in the field of engineering includes limited coursework that make an obvious 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" (EE3& EE4).

> 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. I remember once we took a personality test in one of our classes and all engineers fell 2/3rds of the distance away from creativity. I guess that is how we are programmed. Within one definition we are extremely creative in finding a solution to problems. But we will bang our head against the wall until it cracks when it comes to coming up with something way out there. We are taught to think in a linear way, to find the most efficient and economical way to move from one point to another. We are not going to throw away a known system and create a new one. That's not the creativity that we do. We take what we are given and make it work. Whereas the type of creativity involved in music is starting from scratch and sometimes throwing out the established way to create a new way. That is very difficult for us to do for fear of penalty of failing. (EE5)

This perception is held, to some degree, by all engineers at the beginning of this course. In respect to the conception of creativity as linear problem solving, all agree it is a very important trait for success in engineering. But some recognized there may be a place for engineers to possess that other definition of creativity: "Open-ended creativity is not demonstrated or trained in engineering as in music, so by being exposed to it in this class will help us to be more open to it. That's what I would like to get out of this class" (EE3). This statement, as well as many others, acknowledged a perceived importance of creativity, with an implication of uncertainty existing as to the how it is to play out in their field:

> I don't really know how important creativity is in the field of Engineering. It is rewarded if you follow that with risk-taking and risk management. But at this time I don't know how it plays into the field because the way we learn things is out of a book. Write it down, change it a little bit, and write it down again. As I look ahead to what I expect will be required in the field, I am considering that there might be multiple ways to resolve a problem. (EE5)

The idea of creativity as a process in the field of engineering appeared to exist in the background of educational training. But the engineering students were confident of their rationale:

> I don't think creativity is emphasized because at the undergraduate level we aren't involved in the design process. That comes in graduate study. We do a lot of analysis: like checking out a transistor, figuring out what parameters it operates safely within, and how it can be safely applied to the circuit. There isn't a lot of creativity there; it is more number crunching. We are given problem sets, whether it is thermodynamics or physics, in the form of parameters and tasked to figure out how it works. This is thought-provoking but not in a creative sense. Whereas in music, within a tonality or not, you have to come up with something, which I think is more creative than what we are doing in engineering. It's not that engineering is not creative, just not on an undergraduate level. (EE6)

Even though there was expressed ambiguity associated with the creative process in engineering coursework, a definite awareness of how creativity will be important in their future was apparent: "In engineering you have to come up with something that no one else has designed. To be successful in engineering, we have to think about solutions that haven't been tried and tested. That is the way we get new technologies" (EE1). A more-detailed understanding was exposed in another student's response:

> Our goal is to make something that lasts longer, greater durability. But it also might be to make something economical, maybe sacrificing durability for ease of manufacturing or efficiency. If one process creates a more durable product but costs $10 million dollars more to build or is more difficult to maintain or repair, then we may choose the lesser quality. We are designing circuits in class that does one thing. Then we are asked to create circuit with less parts that will do the same thing. If you are making a million of these circuits, it will make a difference. In music there are particular parameters, such as a particular audience, a musician might choose a piece of less quality to fit the audience. But I think this distinction is a little less clear than our decisions with circuits. (EE7)

As the students described the creative process expected of success in engineering, they also came to a conclusion that: "at its roots our creativity is probably the same as in music. But a musician's creativity is more focused on exploring and discovering, and an engineer's creativity is focused more on how to accomplish a particular goal or solve a specific problem" (EE8). "Engineers are more like problem solvers whereas musicians are more of the creative type" (EE7). Thus one of the cited reasons for enrolling in the course was to enhance their process and skill relating to: "imagination and creativity. It is important for designing things. What is unfortunate is that engineers are typically taught that there is only one answer. This class will teach us to be creative with multiple options in determining solutions to problems. I guess creativity is kind of encouraged because in our classes we are often pushed into trying new things even though much of the homework has just one solution. In our fourth year we are starting to be allowed a bit more creativity. Instead of being asked 'what is the gain', we are asked to build an amp with an amount of gain or amplification and the answer can be done multiple ways. So that is moving us toward being more creative" (EE9). This understanding was shared by all of the engineers in this course:

> Creativity to an electrical engineer is seeing patterns—looking at problems to figure out how to approach them. We look at various ways to solve a problem and find the easiest one, or most effective one. Seeing what is symmetrical, finding the patterns and the easiest way to solve a problem. For a musician, their creativity is more spontaneous when they need to convey an idea and figure out how to achieve that. We are solving problems using numbers, formulas, and laws, and they are solving problems with feeling and emotion. In music there usually isn't one right answer so they must make a choice and go with it. In engineering we usually go to the back of the book. If a problem is authentic in nature, we usually choose the right answer through consensus, an answer that satisfies everything you expect and have learned through the problem solving. If we are building something physical, it must do what it is intended to do. (EE8)

The musicians identified an interest in exposure to contemporary media for composing music since their comfort level was using in paper and pencil techniques and acoustic production of sound. There was one student that voiced initial discontent with including engineers in a course that was required of composition majors: "My first thought of putting engineers and musicians together was why? I didn't really understand because my first gut instinct was that these two groups of people should not be mixing together" (M3). But he, as well as the others, recognized educational possibilities: "I think getting the engineers' perspectives of music in general will broaden my view. They will see things in a difference way, even though we are talking about the same thing. It is like putting on a different pair of glasses to view the same thing. It will be kind of a challenge to see things as they see things" (M3). Along with the excitement of discovering musical perceptions of the engineers, many of the music students were curious as to how this would play out for both groups of students. Along with the curiosity, the musicians discussed a commonality between the disciplines: "We all build things. They have some kind of form in their mind and create something physical. As composers, we do the same but with different mediums" (M3). The musicians understood that: "electronic sound synthesis is based on parameters and circuits of sound" although they did not understand how. Most brought up in the discussion that it will be good "for a musician to think logically about what is happening when sound is created and manipulated as well as for engineers to think creatively about these concepts to make music" (M1).

Although some of the engineers were also not "sure how we were going to work together in the same class because we are coming from such different disciplines" (EE1), all 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" (EE2). Five of the eight engineers had prior musical experiences supporting their excitement when they heard about the course: "I like music.

It is something that I am interested in and can get a credit for it. I definitely thought that when it comes to composition that I have no prayer. But for my part, we know more about how to get around the technology. As we progress, we will see where the skills lay out" (EE5).

It appeared overall that the engineers also saw the commonality between the disciplines: "I'm really big into digital music so I see clearly how the engineering will fit together. When it comes to the projects, I don't know what will come along. But when the time comes, I know that we are very good at getting things done no matter what happens" (EE5). The engineers were also curious as to how they could work together: "for me these two disciplines collide in many ways. I want to see how these two areas are going to work together. There are many overlapping concepts" (EE3). The greatest concern for both groups was "the difference in background understandings and use of terminology or concepts. Of course there are electronic terms that are new to me but I will catch on" (M4). This perceived difference in disciplines didn't hinder decisions to enroll for the course. In contrast, it appeared to encourage some to participate:

> When I heard about the course, one thing that drew me to enrolling is experience collaboration with the music majors. I know they think a little different than I do, but I wanted to get some interdisciplinary thought processes going on. I like my music major friends quite a bit so this gives me a chance to interact with them, where otherwise it would be impossible. One of the differences I see in music majors, as compared to engineering majors, is their ability to creatively come up with unique solutions more readily. This seems to be more prevalent than with my engineer colleagues who follow a regimented process to problem solving. So if you intermix someone that has a creative process with one clear cut way of doing things you will come up with the best product possible as far a design. (EE6)

Course Sequence

The students in this course were provided creative opportunities. Small projects led to a major project near the end of each semester consisting of a musical composition realized by a partnership of one music student and one—or in a few cases, 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 provide a foundation for important student learning beyond the content.To drive home the essence of all content and creative concepts quickly and forcefully, Ken Medema was employed. Classically trained as a pianist and an organist, Mr. Medema earned Bachelor's and Master's degrees in music therapy from Michigan State University, with performance majors in both piano and voice. After working for about a decade as a music therapist, he moved to a full-time career as a singer, musician, recording artist, composer, improvisator, and facilitator, capable in essentially any reasonably well-known genre of music. For the past 40 years, he has performed concerts and other events worldwide, being on the road about 200 days annually in recent years; the rest of his time is spent either in the recording studio or composing. Having employed music synthesis in his recording and performance since the days of the old analog Moog synthesizers, Medema understands thoroughly, on a practical level, the relationship among electronic signals, electronic building blocks useful in generating them, and music that can be developed from them. As a result of Ken Medema being bilingual, communicating clearly in both the language of the musician and the language of the engineer, he demonstrated how a musician and an engineer can combine their individual interests and knowledge for a common purpose. The course content can be found in Figure 2.

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

First Impressions

After the first class period, the music students who were unsure about the combination of musicians and engineers began perceiving connections that could be effective for enhanced learning:

> I really didn’t have any preconceived notions as to the combination musicians and engineers, but after I experienced our first class, it is very interesting to experience the different ways of thinking and how they combine. I was quite astounded at the differences of views between the two groups of students. We are both coming from extremely different plans of study. Although I thought these views were not incompatible, they combine in such ways that generated ideas in ways I had never considered.” (M5)

Many of the musicians realized by the end of the first class period that their concerns of having to review the basics of music for the engineers were unfounded. They discovered that most of the engineers had a basic understanding of music and were very eager to learn more. The engineering students also felt comfortable with the content:

> Since I am self-taught in music I chose to enroll in this course to learn more about music, but I also thought it would be very interesting to work together composing music with someone that thinks fundamentally different than I. An engineer is a process-based thinker. There is a start point, we gather information, and there is an end point. As I work with my music-major partner, when I am my engineering mode, it appears that his brain shuts off. But when he is in his creative thought process, he is amazingly free flowing and creative. This interests me because this is something I desire. By observing and working together, I not only expand how I think but to also understand other people. (EE10)

The engineers “recognized the intense passion that each group has for their discipline” (EE3) and “the strong work ethic associated with successful achievement for each group” (EE1). In class discussions and collaborative projects, the musicians immediately focused on the creative application of the content, concepts, and technology:

> Thus far in the course, I feel the engineers are quieter. They don’t ask very many questions. Whenever I hear of something that I am not certain of and feel that the teacher is moving to another topic before I understand, I always speak up with a question. The engineering students haven’t done that, unless they are called on or if the topic is mathematical. It might be that mathematical topics are more in their comfort zone. (M6)

Similar observations from the musicians were noted both semesters of the course. Even in a setting where students stay after class to clarify the mathematical concepts, the musicians pursued a depth of understanding transferable beyond immediate application. This could be because the musicians in the course were all advanced-level composers. They described this inquisitiveness as “the foundation of what we do. We have to imagine something that that does not exist yet” (M3).

Creativity

Many of the musicians attributed the learning gained through this course to their ability to “express creativity in a way that I am not quite used to” (M5). Working with computers to create, manipulate, and organize sounds was not common practice for any of the musicians. They also demonstrated a curiosity about the element of creativity for engineers:

> I have been wondering what the engineers will get out of this course—what their motivations are. It appears to me that to them a composition is a circuit. To a musician is it a musical work, a piece of music. When the engineers talk about the things in class, they talk about how the oscillator sends out the signal while the envelope manipulates the signal, whereas the musicians discuss about the actual sound. I think there are some differences on how we approach the sounds. As far as creating a composition, I have been wondering how they will go about making a musical piece. Would they be thinking how to get from one triad and to another? Or would they be thinking more about manipulating a variable or oscillator and what will happen if I tweak this setting? I suppose the parameters that guide an engineer's thoughts and consideration would be different than a musician's because they probably have a different end. I think a musician would be thinking more about where the music is going to go. I can imagine engineers thinking step-by-step in the direction for the circuit. I suppose they also might think of where the music can go expressively. (M6)

Before the students became familiar with each other, they were aware of a difference between the disciplines and had preconceived notions of the processes involved: "They create electro-processers and things like that. I wonder how this will interact with my musical creativity. Maybe it will take me to new places in my compositions" (M5). Regardingthe similarities in how the two disciplines employ creativity:

> I think the difference between the two disciplines is in the way each discipline sees value in their creation. It is my impression that the engineers see the creative process in the framework of stability and practicality. A composer has different values in their creations. A musician may not value the rigidity of their composition as an engineer might of their building. (M3)

This perceived difference appeared to be understood and accepted not in a negative framework by the musicians or engineers, but as a foundation for building effective communication. There was an evident awareness that both conceptions of the creative process can be complementary. The musicians' creativity was framed with its own constraints: "The engineers bring ideas to the creative process based upon the music they have experienced. They gain creative aspects from us that they would not conceive of on their own" (M4). The experience of interacting with the creative process within another's framework is precisely what the engineers have described as a perceived deficiency for their future success. Student interaction in this course exemplified a similar contribution for the musicians. It was mentioned by the musicians that:

> We overlook the creative nature of music due to a focus on theoretical structure. It is refreshing for me to consider creativity in musical composing from a new point of view. In engineering, they have to come up with solutions to a problem by taking what they have learned and figure out how to accomplish a particular goal. It is a lot like composers taking ideas from what they have learned or heard, so I'm not sure how creative that is. But working together we might be able to add that personal touch of creating something that develops from a source beyond our prior experience. (M7)

When the electrical engineering students were asked early in the course experience to describe their understanding of creativity within engineering, the responses could be summed up as follows:

> Creativity is important engineering because we wouldn't be coming up with new ideas without it. But I think it is more of a means to come to a solution. We don't do our job just to be creative because we always have the end goal in mind, but we have to be creative to get there. Alternatively, creativity in music is that the end goal is often the product of being creative. It's like let's go have fun being creative and see what comes up. (EE6)

One engineer described how creativity is developed in the engineering curriculum:

> I can get straight A's in my classes without using a lot of creativity because that is the way the engineering curriculum is set up. They want to make sure we can follow a process. But in order to be a good engineer, we will have to break from the established lines of thought. Although this is something important to my greater success as an engineer, it has not explicitly been taught or developed in my engineering training. I have had some teachers say that in order to be really good you are going to have to do something more than what you are doing in this class, hinting at the importance of creativity, but it is not something that has been actively cultivated. That would require we stop crunching numbers for a few weeks. I have observed the musicians compose beyond rules of an established system. That is a new thought for me. To do something different and possibly end up with something great, I would need to take a risk at maybe doing something terrible. That is where creativity plays into engineering, which is one of the things that attracted me to this course in the first place. (EE10)

The final compositions 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 resembling 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). These students clearly communicated that creativity in the undergraduate training of electrical engineers typically leads to one single correct answer and creativity comes in finding the most efficient and economical way to that end point. The open-ended process without a specified endpoint was accepted by the musicians but challenging to the engineers. They often requested a specified sequence and a clarified expectation of the final product.

> It was difficult working on the composition without having some guidance on what is wanted from the assignment. If we were given parameters, the project might have progressed a bit more easily. But this struggle forced us to decide what parameters we wanted. For me not knowing where we were going was a challenge. I believe that without boundaries it is easy to go off in a direction and keep chasing your tail to never get anywhere. I'm used to reaching a goal around designated guidelines. (EE2)

There also existed awareness that this process required an alternative form of creativity. Some found a particular enjoyment in the process: "The work from this class was liberating. Instead of just math, math, math, we were able work on the project and make something that sounds cool" (EE1).

> It would been easy if we had been given a checklist of things for each assignment, but being asked to make a composition without these forced us 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. Hearing other people's compositions midway gave us even more ideas on how we could be creative. The technology provided so many options that it was overwhelming, but since the assignment was open it allowed ideas that may not have occurred with the constraints. It was good overall. (EE6)

The most valuable learning associated with this open-ended process was exposed during the interviews near the end of the course. What emerged was an understanding of an internalized value for solving a problem:

> I've always had it taught to me that everything is done because it is assigned and has a point value, so we all work according to the value. Now I think of a project as more than numbers or to gain points. To be thinking *what am I trying to learn from this* and *if I wasn't assigned this project, how would I approach this* was very different than what I have experienced in my engineering background. Now I might look at an engineering project with more of a goal in mind rather than just to get it done. (EE5)

Many of the other engineers shared similar responses, indicating that they would, with future assignments, consider a personal learning goal that might include consideration of exploring alternative directions in the process and eventual outcome.

When the engineers discussed their experience with creativity through musical composition, it was clear that what was learned included a strong educational impact beyond their initial expectations:

> The creative process was really cool, especially on the final composition. I had a very basic understanding of music composition, but when my musician colleague added more complex musical ideas to my basic ideas, it gave me new ideas about how I can write compositions in the future. Watching this creative process was very interesting. (EE10)

The engineers had often expressed the importance of efficiency in problem solving as one of their primary attributes. Learning the creative process through music composition enabled an alternate conception:

> I really learned that this type of 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. So I suppose in engineering, when I'm creating, it is kind of like building intuition. I know there is a ton to learn before I will be useful in any kind of industry, but with this type of creativity, I can have a lot of fun learning. (EE5)

He continued describing his conception of the creative process:

> 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. As I look back, it would have been great to realize this before we got to the final project because we could have taken greater advantage of this knowledge. Experiencing this through music composition provided an interesting take on the creative process. (EE5)

The learning experience of the musicians often focused less on the creative process than on the contribution of the engineers to their creative flow:

> I had some ideas how I wanted the things to sound like but I wasn't sure how to make it happen. It was awesome how the engineers knew precisely what do to: *you should do this with this knob over here*. Granted I was trying to understand the technology and had a rough idea of how it was accomplished, but my partner knew and helped with that part of it. I probably could have worked it out but I was fascinated to hear the engineer's ideas and watch them work their magic with the technology. It was organic development. (M5)

The course appeared to provide valuable learning for both groups of students in the understanding and implementation of the creative process.

Learning to collaborate and communicate effectively

One important learning expectation involved collaboration between the two disciplinary groups. Both disciplines have focused curricula that require an abundance of time working with their disciplinary colleagues. General education is intended to help students widen their perspectives, explore relationships among subjects, and build critical and analytical thinking skills while interacting with students from a broad range of academic areas. All students in the course recognized an importance of such interaction, not only within the purpose of general education, but also as an essential development within their own discipline:

> I am excited to be working together with someone from a different area because this is something that we will have to do out in the industry. We will have to work with people and communicate ideas to people who don't have our education or background. We must try to help them understand what we are doing and talk in terms that they will understand. So I guess I am excited to broaden my horizons and try to get an experience on how to do that now before I do it in the industry, where it is a much bigger deal. (EE1)

The electrical engineers indicated an importance of clear communication when interacting with those that possess different levels of understanding. One engineer described this as communicating with the end user: "It's easy to put specs on a piece of paper but there is more to learn when you talk with someone who is going to be the end user. If I can figure out and accommodate their needs, and inversely what I need from them, such as the data to build something, then I can be successful" (EE11). The musicians considered the same concept associated with expectations in the career of music: "There are so many combinations in jobs that I am quite excited that I might find new ideas for future career paths. There is quite a bit of overlap with the technology between electrical engineers and music" (M5). Both groups, electrical engineers and musicians, recognized the importance of enhanced communication skills associated with their own discipline. One engineer eloquently described recognition of need for enhancing communication skills:

> I am used to working with engineers and even share an apartment with engineers, so working with someone whose background is different is a very good experience. After finding that we had a lot of things in common, it was just like working with anyone else. This is one of those things that will be useful to me. There is a bad stereotype that engineers don't know how to communicate with anybody, and it's partly true. We get bogged down in technical classes and develop advanced knowledge of our field that we find it difficult to step back and communicate ideas on an appropriate level. I have been

> told many times that, as an engineer, I will need to be able to communicate my ideas. I will be much more valuable if they won't have to hire someone to mediate between me and a client. But it goes the other way too. I have to learn about other's fields as well. Every time my partner and I went in to make a composition, I thought we would just plop a couple of things down and say *that sounds good*. But I discovered composing is a lot more structured than I originally thought, which I actually liked because I am used to that kind of thing. There is also more of a technique to it than I has previously considered. Learning the composition process is very interesting. Learning about other disciplines is important so I can talk about things without sounding like an idiot. (EE1)

As the semester came to an end, the musicians and engineers completed their collaborative compositions. Prior to the final in-class presentation, all students expressed excitement for the class performance and had no reservations in discussing their contribution to the project. They each had their own story to tell. Most narratives began with the students describing the initial intent behind the decisions that led to the musical composition and what parts of the project could be attributed to which student's decisions: "Did it sound the way I heard it in my head? Not entirely, but it ended up being a mix of each of our ideas" (EE10). In the collaboration, both the engineers and the musicians described their experiences 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 in independent directions and never get anywhere" (EE2). Most described that they were not used to collaborating. Making decisions independently 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 a little bit. It was something I learned I had to do and forced me to let go a bit. We worked very well together" (EE10).

In all instances, 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. For the engineers, this was experienced when making final decisions on the musical outcome. The musicians often described similar experiences of relying on the engineers when manipulating the technology: "There were times when working on our composition I couldn't figure how how to accomplish the musical goal with the technology. He would say *let me sit down here* and then make it work. As an engineer he understands the details about how the technology works, enabling my ideas to sound" (M2).

In many examples, both groups of students described collaborative decision-making either by trusting in another's ideas or by generating a new ideas from the other's thoughts: "Working together was awesome. He [the engineer] had a basic song ready to go, so we were able to use the form from his piece and build upon that. At one point we sat down at the piano to notate his vocal melody, which we then would augment. Since his motif used a repeated rhythm, my ideas were mostly the pulsating gestures build upon what he already created" (M2). Each made a contribution to the final product in a variety of creative ways.

It was common for the team partners to show their appreciation for each other's contributions, often humbly diminishing their own impact on the final product as seen in the following discussion by two engineers from a three-person team:

> Our composition sounds really good. Our musician partner had a well-thought-out vision, so I feel we made a small contribution. We, the engineers, had a say on what the sounds

> were to sound like. We worked with tweaking the sounds and our musician partner put the musical touches to it. We manipulated the programs and he fulfilled the vision. I took over at those times when there were technology problems. (EE4)
>
> I’m not sure we had much of an opportunity to be creative because the basic plan for the piece was designed by our musician colleague. But that is not where my comfort level is anyway. (EE12)

What is interesting is that their musical colleague, interviewed at a different time, identified the engineers’ contributions as foundational in the development of the composition, enabling him to be able to create the musical components through their capabilities of working the technology: “I wouldn’t have been able to achieve the final product as it turned out without their help. We did this together with equal input” (M5). It became clear in our interviews that assistance in areas where the other felt less confident was perceived as strong contributions to the final product. Individuals from both groups learned to rely on the strengths of the other and described the experience as among the most powerful learning that occurred as a result of the course.

To bring to further evidence of learning that occurred as a result of the cross-disciplinary interaction, the following conversation between partners exposed how two skill sets interacted in the project. Each student demonstrated a particular pride in his contribution as well as recognition for the symbiotic creative process:

> (M1) “Although my engineering partner had some musical experience, I made many of the musical decisions. His contribution was more focused on troubleshooting problems that occurred with the software.”
>
> (EE6) “I would say keystrokes on the keyboard were made by my musical partner but I did most of the work on the manipulating the generated content.”
>
> (M1) “He was a little more adept at making things happen on the software. In some ways, his technical contributions made it possible for me to make my musical goals possible.”
>
> (EE6) “I found it mentally frustrating when creating a sound when I had a specific sound in my mind. Even when it came close, the final product wasn’t exactly what I wanted so I had to keep working to get it just right. As I became more familiar with the technology, it became easier to get to the desired product. There was a steep learning curve to become proficient with the technology. I definitely have a greater appreciation for those who use the software and are successful with it.”

The students not only learned to recognize and respect skill-sets of other team members, but they also experienced a problem-solving process in ways they hadn’t previously considered: “The most important thing I learned from this course came through the collaboration, working with another person in a very different context. I think seeing problem-solving in music is powerful” (EE5).

When one part of a team needed guidance or assistance, the other contributed in ways that facilitated a partnership in the creative development of the composition. In the following team discussion, the engineer had no musical training prior to this course but was actively involved in the process in ways that were essential to the overall development of the composition. The musical partner explains a bit about the experience:

> It was interesting how we went at the final composition. I originally thought we would come up with something organic but the others wanted to use a piece that had been written earlier. This collaboration impacted my creative process because we came to the project with different ideas about how to go about things. For me the primary focus was the aesthetics of what we wanted to accomplish. My musical background was different than his because his previous exposure to music was in the popular vein, so he wanted to do something similar to what he had in his mind. But we morphed into a non-traditional soundscape. We both collaborated with what 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 we made it how he had in mind. As we would go through the project he would say *we need something here like a low sound*, or, another place, *we need something high, sparkly on top.* So I tried to realize what he had in his mind. I could add the musical line and he knew how to use the technology. He knew specifically what kind of sounds he wanted and how to create them. (M7)

Most interesting, the engineer, in his interview at a different time, explained the same collaborative story but 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. He would ask *what do you think would sound good with this?* and I would come up with a sound. 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 so funny to hear us talk, but he knew what I meant. (EE1)

This example illustrates the collaboration within each group of musicians and engineers. It described 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 and we as engineers know about another side and then work together on a project" (EE9).

> A very important thing I learned was working with someone that is not of like mind. I came to the project with a check list 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. We both wanted to get the composition done and he was more focused on the creative aspects and I was more focused on the technical aspects of making sure all criteria were met. 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 an experience in problem-solving that was founded upon circumstances that partially reflected the individual's expertise in combination with the availability of other necessary multi-disciplinary experts. This appeared to be one of the key factors supporting enhanced learning in this general-education offering.

Enhanced learning

When considering the results from this particular general-education course, several obvious strands emerged, the most obvious being an enhanced skill in problem-solving. The construct of the course with two diverse groups "pushed everyone in areas outside of our field. I think cross disciplinary education is challenging because it develops an open mind" (M2). The student went on to describe how disciplinary content was difficult to understand by those in the contrasting discipline forcing them to "rely on each other. This created camaraderie not available in a tightly structured course focused only in one discipline." The varied processes of problem-solving involved in each discipline brought an awareness of possibilities to the students:

> 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 progress was expanded beyond what I typically could have come up with. I guess when working with others, ideas that are outside of the typical sequence or different than mine are useful. (EE10)

Both groups of students discovered a realm of possibility pertaining to the problem-solving process that could transfer into their applied discipline: "What I learned was when working together with another in problem-solving, the collaboration valuable for learning other people's viewpoints. It is a wonderful learning experience to grow with another around music" (M2).

Students discovered options for problem-solving that included: (a) pursuing options beyond a normal framework or structure within their discipline, or in other words, considering creative alternatives that might generate an improved outcome; (b) deliberation of notions beyond their own that influenced the direction of the problem-solving process; and (c) recognition that effective communication requires consideration of another's beliefs, understandings and intentions, as well as flexibility within these considerations.

> I mostly learned how to communicate ideas to someone else, especially the abstract ideas. In industry it is an important skill to be able to communicate and clearly explain ideas because they don't have the vocabulary and the conceptual background of what we are doing. It is also important to know what the client wants before we work our projects. (EE3)

In addition, the students uncovered alternative directions of personal goals. Each student's account is unique, but important, in relation to the contribution that this course provided:

> I have been thinking about practical applications of the things we have been learning. It's been getting my gears turning. Since this was kind of like a survey class, new understandings of things like the sinusoidal waves and the building blocks of sounds opened a new door for me as a composer, especially the exercise at the beginning of the semester that required us to explore and create sounds on our own. (M5)

When students re-conceptualize what they know and can do, then the opportunity for growth becomes substantial as supported by the theories of Cognitive Dissonance described by Festinger, Vigotsky, and Rogers [20].

> Going into the final, I never felt so ill-prepared. In former years I was always confident on how to put things together and make a composition happen. But in the electronic world there are no lines and spaces on a paper. There is just time and space and how to fill it. It was kind of intimidating because the medium was such a new thing for me. Once the engineer and I worked together, things started to click. We were able do unique things with the technology in each section. Questions started to come up as we talked together. It was less about specific rules of music and more about what color are we trying to make here. I was less concerned with making things line up than if I were composing with pen and paper. (M2)

The point when students' looked differently upon their own discipline was after they completed the collaborative assignments: "Working in groups was an effective contribution and that is something that normally occurs later in the study of engineering" (EE2).

> The most important thing I got out of the course was working with other people that are fundamentally different. I noticed in class that the engineers worked more individually and did not appear to have a much fun with their work. The musicians were talking and laughing all of the time, enjoying all aspects of their work. Getting that wide range of dynamics is a good experience for working with people in the future. (EE4)

> Working as a team is something that is very useful from this course. Working as a team with a set of engineers is good, but working with someone outside of your discipline if very important. I expect that in the future we will be working with a variety of people in corporations. This might be one of the most important aspects of learning from the course. (EE8)

Beyond the collaboration, communication, and creativity, the engineers also expanded upon the content knowledge of electrical engineering:

> I really enjoyed talking about the spectra, breaking it down into its sine and cosine components, and then the frequency domain. I am taking a course right now in which we talk quite a bit about that. It's really good to keep it fresh in my mind. Because I had those classes, I got a lot from those discussions. It solidified some things that I wasn't quite sure about. Now I understand the frequency domain, how it gets shifted down. (EE4)

Connections to concepts and knowledge from other courses were mentioned several times by the engineers: "One real nice thing is that some of the concepts lined up well with other courses we were taking, like linear systems. FM synthesis happened to be discussed in both of my classes on the same day. We also talked about amplitude modulation in this course and not too long after that we talked about it in another class. It was pretty cool how some of the concepts aligned and informed both courses" (EE8).

Several students also mentioned how learning to use the technology, although not the specific technology they use in electrical engineers, was still good learning by going through the process of figuring it out: "Figuring out how to use the technology is what we do in engineering, so in a way the skills of figuring it out is something that can transfer into my engineering development" (EE3). Others looked more deeply into the technology and applied the engineering background to enhance their current understanding: "In working with the technology, I looked at things from the engineer developer. Why was it designed this way? I think that if a developer is creating a software, it would be very important to ask some who are using it what they want from the software" (EE1).

> I find the science of music very interesting, and it overlaps very well with electrical engineering. I wanted to have a better understanding of the science of sound, and making music with the technology was a bonus experience. The specific making of music using the technology may not be directly useful in my future but the skills and math of how sound works can be transferable. I think it would be cool if I specialized in combining music in my career as an electrical engineer, but I'm don't think many schools have a big musical section of electrical engineering. But it would be real cool. (EE7)

Of equal importance through this cross-curricular experience was exposure to another discipline: "I also learned to appreciate musical works that I probably wouldn't have ever listened to in my entire life. Even if the sounds were initially harsh, I now appreciate the music like this, and those who create it" (EE6).

Interestingly enough, this statement was made by both the engineers and the musicians. The music students also discovered aspects about their own understandings that resulted in alternate considerations. Many described an expansion of their disciplinary framework: "I thought I knew a lot about music but over the semester I have learned how little I know, or at least how much more there is to know" (M3). Reflections of the musicians often focused on a recognition of compositional options: "Electronic music takes the creative process to a whole other level, using sounds and soundscapes you can't access acoustically or generate those sounds for expression" (M7). Most musicians' concept of compositional possibilities was expanded beyond the limits considered prior to taking the course.

> It was initially difficult composing with technology rather than paper and pencil. This was the first time I had ever done anything like this. Usually, my compositions were based on theory and other rules. But having experienced this, I really enjoyed it. Hopefully, I can learn the programs more intricately because I know it can do so much more. (M7)

The musicians also expanded their understanding of others' aesthetic sensibilities. This is particularly important when composing so the listener can find a connection and possible enjoyment from the composed piece: "I will take a little of what I learned from my new engineer friend as far as how aesthetic preference of others can influence on my own musical ideas" (M4). Through interaction and collaboration, many musicians discovered a need to compose with a recognition of what others might relate to. Each musician learned to make concessions to the engineers' sensibilities and shared the creative process, which resulted in an enhanced composition.

> Without the engineers, I think the entire focus of the class would be different. It would have been very easy for musicians to only focus on the aesthetic side, but having the engineers forced us to explain what makes the musical piece interesting. Without both groups we would have stayed within our comfort zone. It helped balance the class with depth and explanation to help us all understand what we are doing and why. (M4)

A few musicians even expanded their own appreciation for music composed through the use of technology: "I was entirely opposed to electronic music prior to taking this course. I learned what scholarly electronic music is and that there are many different varieties. I feel much more comfortable now that the electronic medium is something that I can explore. Now I found out I can use the technology as a medium” (M3). All musicians left the course with an interest to include electronic music as a vehicle for future creativity. “I have a better foundation for doing electro-acoustic or just electronic music in the future. It’s given me a clearer appreciation for this type of music” (M5).

> One of my favorite things about late romantic music is how they take a theme and never recognize it until the middle. They will change the sound color, melodically, and rhythmically. I found the technology allows you to do that in ways that I had never considered. Now there is a whole new world available that technology makes possible. (M3)

Challenge experienced

There were difficulties with students not fully grasping how to use the technology when they began working independently or in groups. We discovered that students needed hands-on experience in addition to demonstration. It was uncovered that the students were spending more time than anticipated trying to manipulate the software: “Trying to make the technology work was immensely frustrating because it held back the creative process” (M2).

> The software was by far the most challenging aspect of the course. Getting the software to behave was difficult. We would go to the owner’s manual and find out we had forgotten to check one box or something like that. With the two-dimensionality of the screen, it is sometimes difficult to see if something is not switched the correct way. (EE11)

This was addressed the second semester with programs that could be manipulated on any computer.

It was discovered that some of the musical lectures were at a level beyond what the engineers could understand, and the same for the engineering lectures for the musicians: “The engineering concepts hit me like a brick wall” (M3). This was addressed the second semester with additional time provided after class to clarify confusion and to encourage peer assistance. Additional short assignments also helped students understand specific content.

The most challenging aspect was scheduling group work. Both groups, engineers and musicians, had very busy schedules that did not fit together easily. “Arguably two of the most busy disciplines on campus” (EE5).

> The most difficult time was finding meeting times. I was surprised how many hours musicians spend beyond the normal school day. Balancing schedule with someone that has a different schedule than you is also a learning experience. (EE1)

Working with the varied schedules was a learning experience for the students. Working with someone outside of their discipline required that the students accept the ownership of the learning process. In addition to the challenge of students working within another person’s schedule, the lab was often in use by others. Many expressed “feeling self-conscious in the lab, working on a musical project when there were other engineers from other engineering courses in the room working on projects” (M1). Since the musical assignments required audible sound, “it was a bit of a bottle neck for creativity when you have others in the room scowling at you making noise, and others trying to get into the room wanting to use the computer” (EE5). The second-semester course was moved to the Music Technology Lab, where students could work with headphones. The software being downloadable to the students' own computers also made teamwork practical outside of the lab.

Some students expected a little more structure to the course in the way of defined expectations for the assignments. A few expressed an added level of stress not having been provided specific parameters for the projects. Among their concerns was the additional time that was consumed by making decision pertaining to the content and structure of their compositions. Although their concerns were considered as possible revisions for the second semester of the course, with such strong indications that the creative process was enhanced by the open-ended nature of the assignments, no change was made. "A lot of the assignments tended to be vague in description, but I liked that because it forced us to be more creative" (EE13)

The professors thought it was interesting when students requested more assignments throughout the course to help them learn the software and experience the creative process in smaller doses. For the second semester, students were provided additional hands-on experiences manipulating the software in class and through a few shorter assignments focused on specific learning goals. This helped the students absorb the information and develop the skills. In addition, step-by-step tutorials of the software were also made available as reminders for using the programs.

Another enhancement of the course for the second semester was to set up the classroom as a lab where each student could work with the technology with guidance and feedback. This way, the students were able to ask questions when they ran into problems. This was accomplished by using software that could be downloaded to each student's laptop and to home desktop computers.

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