Abstract – FINE392: Technology Art Studio is a unique course developed as a collaboration between Engineering and Fine Arts at the University of Waterloo. Both disciplines require the application of significant creativity and problem solving, and the unique context of this course provides fascinating opportunities for immersive, cross-disciplinary learning, not just of the immediate subject material, but of working methods and approaches. This paper describes the course learning goals and syllabus, as well as providing anecdotal reports from our experience in three offerings of the course, and from students in past offerings. We also describe a study we are piloting in this Winter 2006 term, to examine qualitative indicators of knowledge building and transformative learning. That is, to determine how much cross-disciplinary fertilization is taking place and, if possible, how it is occurring. The eventual goal of the research is to draw conclusions about how to effectively facilitate cross-disciplinary fertilization in this course, and in the broader context of other multi-disciplinary interactions.

Index Terms—collaboration, interdisciplinary, cross-disciplinary, studio courses, sculpture, engineering

Introduction

Engineering design is a practice which requires the ability to reason critically and creatively. Traditionally, design as a discipline was taught only in select programs within faculties of engineering (e.g., Industrial Design Engineering, Systems Design Engineering). Creativity as a subject was all but ignored in traditional curricula, likely due to the difficulty in “teaching” creative practice with the rigour and strict assessment models which characterise typical engineering programs. Students, it is generally reasoned, will hone their ability to think creatively through practice. While it is true that creative thinking develops through practice, students must be provided with projects which challenge their current level or mode of creative thinking, in order to develop further.

Thankfully, Engineering curricula have in the past decade evolved in this respect, to the current point where nearly every engineering undergraduate program includes some form of capstone, open-ended group design project. In some cases, the opportunity exists for these projects to take on an “interdisciplinary” nature, which in the context of these programs means engineers from different departments collaborating with each other. This is excellent preparation for the type of interdisciplinary teamwork which will characterise many engineers’ post-graduation work environments.

At the University of Waterloo, we have introduced (in addition to the core capstone design project) a novel cross-disciplinary elective course, Technology Art Studio, which challenges engineering students to think creatively in a context entirely different from the traditional “design project.” Engineering students collaborate in inter-disciplinary groups with sculpture students from Fine Arts, on technology-mediated sculptural works. While there are many examples of technology art courses designed for arts majors, there are very few (if any) courses which actually pair engineering and fine arts students together to work on projects. Both disciplines require the application of significant creativity and problem solving, and were quite close prior to the industrial revolution and the increasing specialization seen in technical disciplines. The unique setting of this course provides fascinating opportunities for immersive, cross-disciplinary learning, not just of the immediate subject material, but of working methods and approaches.

The purpose of this paper is to describe the format and implementation of this course, describe anecdotal outcomes from the first three offerings, and preview a study we are undertaking in the current (third) offering to attempt to assess the level and mechanisms of effective cross-disciplinary learning.

Background

1. Research context

The literature is rife with examples of “interdisciplinary learning,” particularly for engineering students; so many that a complete survey here would be impossible. These learning experiences fall mainly into the following categories:

- Interdisciplinary projects within engineering: students from different disciplines within engineering collaborate, generally on upper-year design projects. For example, in the Interdisciplinary Design Program at the University of Illinois at Urbana-Champaign. At UW, projects like the Midnight Sun solar car and Waterloo Aerial Robotics Group are further examples.
- Engineering & business: students from engineering and business may collaborate on case studies or mock projects around intellectual property and commercialization of technology [3, e.g.].
- Engineering & humanities/social sciences: application of problem-solving methods from humanities and social sci-
ences to technical problems. While courses may be team-taught by interdisciplinary faculty, students are generally from the same discipline [1, e.g.].

- Engineering & English: technical communications/writing courses. Again, faculty may be interdisciplinary but students are generally all from the same discipline. For example, the University of Alberta’s ENGLISH199: Essentials of Writing for Engineering Students, open to Engineering students only, is taught by faculty from the English Department.

There are two key aspects of FINE392 which result in an opportunity for novel research into interdisciplinary learning: there is little or no research on collaboration between engineers and artists, and much of the extant literature focuses on teaching specific topics to non-specialists, not on collaborative courses at the student level. Despite these differences, existing studies on the effectiveness of interdisciplinary collaboration emphasize the importance of this model and provide support for the proposed methodology and assessment tools [4, e.g.].

In addition, there are numerous successful Art and Technology programs, particularly in the United States and Europe (e.g., Ivrea in Italy, ITP at New York University, the Media Lab at MIT). However, there appear to be few if any studies on interdisciplinary learning in these programs, possibly because they admit students directly and generally at a post-graduate level. Thus, they may not consider themselves cross-disciplinary in the same sense as FINE392 since all students are based directly in the program.

II. Course Description

FINE392: Technology Art Studio is a unique course developed as a collaboration between the Faculty of Engineering and Department of Fine Arts. This section describes the course in general terms, as well as specific details which differed across the three offerings.

FINE392 was initiated as a means to provide an innovative learning opportunity for both engineers and artists, and to address (in some albeit small way) concerns among engineering students about the lack of choice and creative outlets in our undergraduate curriculum. The course has been offered annually in the Winter term (Jan-April) since 2004. For purposes of accreditation by the Canadian Engineering Accreditation Board (CEAB), the course counts as a Complementary Studies Elective.

Goals: There are several different goals for this course. Institutionally, we hope it will form the basis for rapprochement and expanded interaction between Engineering and Fine Arts. We feel there is much to be gained from this inter-disciplinary dialog and envision greater collaboration at the undergraduate, graduate, and research levels. Pedagogically, the main goal of the course is to expose students in each discipline to the thinking and methods of the other. By collaborating in interdisciplinary groups, participants learn to express themselves and their ideas without the shared jargon of their discipline. In seeking ways to explain engineering and artistic concepts within their groups, students expand their own understanding of the topic just as an instructor achieves greater mastery of a subject by having to teach it. Engineers in the class are exposed to alternative ways of approaching the creative process, as a well as alternative motivators for design. Artists learn about technology as a medium, technology art practice, and the potential and limitations of the medium. Their practice will be influenced even if they don’t incorporate technology directly in their works, much as a painter’s conceptual toolbox is influenced through the study of sculpture, even if they never sculpt beyond the context of study.

Admission: The course admits an equal number of students from Engineering and Fine Arts, typically seven of each, and registration requires instructor permission. Admission of engineering students is generally restricted to third- or fourth-year, and while in principle open to all departments, the course tends to attract students from our Electrical & Computer (ECE), Mechanical (ME), and Systems Design Engineering (SYDE) programs. Online enrolment for the Winter term takes place in October, and Engineering students are required to submit a Letter of Motivation to the instructors in September. The size of the Fine Arts program allows admission of sculpture students into the course to be somewhat more informal: by third year the instructor knows all the students quite well, and admission is generally done by invitation.

Organization: The course runs over a 13-week period from early January to early April, and is structured as a one-hour lecture slot and a three-hour studio slot, weekly. The course is co-taught by faculty from Engineering and Fine Arts, with both instructors attending all lectures and studio sessions. Lectures take place in a room with cinema seating and full-wall electronic projection of slides, video, or online information. Use of the lecture/studio slots is flexible: early in the term, both slots are used for lecturing, while during the later stages both slots are often used for group work/assistance on projects. There is no TA or lab support, although students are generally supported to different degrees by resources of their home departments (e.g., students have access to the Fine Arts wood shop, the Engineering Student Shop, and various levels of electronics equipment/assistance depending on the engineers’ home departments). The instructors also make themselves available and have provided a significant amount of out-of-class support during the heavy design and fabrication stages of the works.

Content: The curriculum includes lectures on formal sculptural concepts, collaboration, installation work, user-centered design, and technology art history. Three-hour workshops are given on introduction to sculpture (for engineers only), electricity & electronics (for artists only), and microprocessors. With the exception of the first two workshops, students attend all lectures equally. These topics are supplemented each term with presentations from visiting technology artists, visits to local galleries as appropriate, and critical discussion of examples of current practice. The course culminates in a three-day public exhibition of student-created work.
Assessment: Several projects are assigned through the course of the term: 2-3 short projects in the first 4-6 weeks, and a larger 6-8 week project during the remainder of the term. Most of the projects are done in interdisciplinary groups, with students collaborating on their works during studio time and outside of class time. All projects include a formal group critique, where students present their work for critical assessment by the instructors and feedback from their peers. Works are assessed on the extent to which they meet the goals of the assignment, their strength outside the context of the course, and formal sculptural aspects. All members of a group are assigned the same grade for the work. The bulk of the grade assessment comes from the end result of these projects, with an additional 10%-15% of the grade assigned for class participation. Projects which have been assigned:

- **Book Project**—Students are provided with a selection of used books and asked to choose one and create a sculpture using 100% of the material from the book. They may use the book content as conceptual material for the piece, or make it purely formal. Assigned in Week 1 of 2004 & 2005 as a one-week individual project.

- **Egg Launcher**—Students are asked to choose a major art movement and create a sculptural work made 80% from corrugated cardboard that will launch an egg the furthest. The piece must be conceptually and/or visually in the style of the chosen movement. Assigned in Week 1 of 2006 as a two-week group project.

- **Toy Hack**—Students are asked to choose a toy and subvert it in some way. The piece must include electrical or electronic components. In 2005, assigned in Week 2 as a two-week individual project. In 2006, assigned in Week 2 as a four-week group project. Not used in 2004.

- **Freeing the Mind**—Students are asked to create an object incorporating electronics, and given the Star Trek “Tricorder” as an model of a fictional device which can be assigned whatever functionality comes to mind. Importance is placed on how the stated functionality informs the physical form and the experience of the user. Used in 2004 & 2005. Assigned in Week 3 as a one-week individual “paper” assignment (sketches and concept only). Re-assigned in Week 4 as a three-week group project.

- **No Holds Barred**—A “paper” assignment (sketches and concept only) in which students are asked to draw inspiration from technological items in our environment, and propose a piece which subverts that commonplace technology into an experience which could be considered art. Implementation issues are not considered, and the emphasis is placed on the form and meaning of the piece and the experience of the viewer in interacting with the piece. Used in 2004 only. Assigned in Week 6 as a one-week individual project.

- **Final Project**—An open-ended assignment to create a technology-mediated sculptural work. Assigned in the last 6-8 weeks of the course, in inter-disciplinary groups ranging in size from two to four members.

Past Offerings: The substantive differences over the three offerings of the course (2004-2006) were the assignments which were used, the makeup of the class, and the methods used to assign students to groups for group projects.

- The 2004 offering had 13 students in it: six artists (one 3rd year, five 4th year), four ECE (one 3rd year, three 4th year), two SYDE (one 3rd year, one 4th year), and one ME (2nd year). After the first individual Book Project, the proposals from Freeing the Mind were used to assign interdisciplinary pairs for the implementation portion of that project. The No Holds Barred proposals were discussed in class and students were asked to form themselves into groups for the final project.

- The 2005 offering had 15 students in it: seven artists (one 3rd year, three 4th year, four grad), one ECE (4th year), five SYDE (three 3rd year, two 4th year), and one student registered in Independent Studies (Faculty of Arts). After the first individual Book Project & Toy Hack assignments, the proposals from Freeing the Mind were used to assign interdisciplinary two- and three-person groups for the implementation portion of that project. These groups were kept for the final project.

- The 2006 offering had 14 students in it: seven artists (three 3rd year, three 4th year, one grad), one ECE (4th year), two SYDE (3rd year), and four ME (two 3rd year, two 4th year). Students were assigned in interdisciplinary pairs during the first lecture and immediately assigned Egg Launcher as a group project. Pairs were re-assigned for Toy Hack, to allow students to collaborate with a different partner. For the final project, students were asked to suggest their preferred partners and group size, and instructors attempted to accommodate while ensuring each group contained artist and engineer, and maximizing exposure to new partners. This resulted in two groups of four, and two groups of three.

Course Outcomes

The outcomes of the course can be divided into two categories: the physical works of art produced by the groups in response to the various assignments, and the degree to which students’ thinking and practice will be affected by participation in the course. At present, we have only anecdotal evidence of the latter: the extent to which students self-report the influence of the course on their practice, reflections from students’ sketchbooks on the course content and their collaborations, and instructors’ observations of what worked and didn’t work. In Winter 2006, we ran a pilot study, to look more scientifically at the cross-disciplinary learning taking place in the course. This study is described in more detail in the next section. This section provides examples of student work from 2004 & 2005, anecdotal evidence of course impact, and reflections on aspects of course implementation.
I. Selected Student Works

The following works are representative of the magnitude and quality of the final project pieces created by students in the 2004 and 2005 offering. They were shown during the three-day annual end-of-term exhibition titled t’art: Technology Art Exhibition, in the main foyer of the central engineering building on campus.

**Aural Ice:** In a quiet secluded space, a block of ice hangs by chains from the ceiling above a glass water-filled bowl. As the ice melts, drips falling into the bowl generate soothing ambient notes, creating a calming zen-like experience. The artists used a webcam inside the plinth supporting the bowl to detect ripple patterns in the water. MATLAB is used to process the images in real-time and generate a tone which is a function of the location of the drip in the bowl.

*Fig. 1. Aural Ice (2005) by Natasha Graham, Ryan Grant, Dawn Stafrace*

**Red Retold:**

Passersby are interrupted by the ringing of a phone. Picking it up, they hear a first-person narrative. When the narrative ends, another phone rings, and a second person narrates the same story. Eventually, viewers hear the Woodsman, the Mother, the Wolf, the Grandmother, and Red Riding Hood herself relate their versions of *Little Red Riding Hood.* This piece addresses issues of individual perspective of events and reminds us to continually question what we hear.

*Fig. 2. Red Retold (2004) by Nicole Grinstead, Joanne Hastie, Kuo-Cheng Tong*

**Post-Critical Zeotrope:** This dynamic piece is a homage to Eadweard Muybridge’s revolutionary nineteenth-century series of images, *The Horse in Motion.* Muybridge took six years to capture the stop-motion images of a horse in full gallop, after being retained by Leland Stanford to confirm that there was a point in a horses gallop when all four hooves were off the ground. The images are reanimated and played on a laptop computer, which in turn rotates on the end of a boom in a circle reminiscent of a racetrack, “giving the life back to the original source of observation, the once-living horse and rider.”

*Fig. 3. Post-Critical Zeotrope (2005) by Matt Millard, Rick Nixon*

II. Anecdotal Evidence of Course Impact

Informal guided-question questionnaires were administered by e-mail in 2004 and 2005. Students were asked to comment on course content, workload, group assignments, projects, and outcome. In addition, in 2005, students were asked to keep online “Idea Journals”: a combination of design log, sketchbook, and self-reflection on their collaborations, the course, and its impact on their practice. No grades were assigned for these journals, so they were in effect voluntary. Comments from the questionnaires and journals indicate that the course was a positive experience for students and was in some cases an influence on students’ thinking and future practice. A sample of anecdotal responses are presented below.

“Collaboration is different with each person you work with, and it is very hard. There must be a balance so that no one feels like their ideas are being ignored, etc. Collaboration is like a marriage; you have to work at it. ... I increased my tech vocabulary, making it easier for me to read and understand books that I am interested in. ... This course opened a whole new world for me. It is like I am standing in a doorway, overlooking a huge magical land of possibilities. ... I realize now what type of art I will concentrate on in the future. ... I am interested in making more tech artwork as soon as I can increase my technical knowledge.” –*artist, 2004*

“I am particularly struck by how frustrating it was to bring all my engineering friends to the final exhibition, and have them all comment on the technical quality of the work, without ever touching on the artistic. ... Something very important that I gained from this class, and that I will take with me wherever I go, is a broader sense of the capabilities and the possibilities for the engineering skills I have. Never before have I been challenged, as I was in this course, to really think about the meaning of what I was making; not only IF or HOW I could build it, but whether I should and whether it would be a good final product. Not just good to sell or good to buy, but good just good.” –*engineer, 2004*

“[This course] was every bit as exciting as I hoped it would be when I read the initial course offering description. In the end, however, the ultimate lesson I learned is how vastly I underestimated the difficulty of artistic practice.” –*engineer, 2004*

“Certain stereotypes abounded: the engineers were aesthetically challenged, the artists were unconcerned with real life issues, etc. The workshop aspect and the artist/engineer pairing forced everyone to confront those stereotypes and work through them. I can assure you that artists have an exalted view of themselves, and it is both reassuring and daunting to see that high opinion questioned. I dug my heels in more than once over an aesthetic concern. Contrary to what I expected, my engineer partner was very committed to the aesthetic. Conversely, I found myself arguing for certain mechanical decisions that...”
drew from sources unavailable to the engineers. In the end, the playful back and forth made the most inroads into dismantling the barriers between the students and their respective disciplines. ... I think that the course helped demystify technology, or at least it partially demystified the gatekeepers of technology. By this I mean I always felt suspicious about tech oriented art: Was it too gimmicky? Doesn’t it always break down? Is it too big a pain to access? Do I have to go to weird surplus stores? But in the end, I see a whole world of possibilities, and the tech component is a vast archive to research and deploy.” –artist, 2005

“This course has greatly broadened my knowledge of engineering, contemporary art practices, and has opened me to wider possibilities in my own work. It is akin to learning another mode of communication. I was familiar with drawing, painting, printmaking, computer images and sculpture. But now I am more aware of the role that technology plays in those areas and I have been turned towards thinking about the implications of technological advances. As well, I am now more comfortable with the idea of having an artistic idea that might have some elements that would have to be contracted out or collaborated with if they exceed my specific skills. ... In fact a real highlight for me in the course was learning about [my partner’s] education and what engineering is generally about. As much as we talked about our projects, we equally were very interested in each other’s training and how that knowledge might be applied to our own practices.” –artist, 2005

“...while we were doing the electrical parts we all took turns soldering and connecting switches and modifying the answering machines. It was really great. On another topic I am impressed that i came up with an idea for a tech project outside of the tech class. It is interesting to realize that this is already playing a part in my regular stream of consciousness. I am using the technology that I have learnt in this class to think of things that a few months ago would have never crossed my mind even as possibilities. It is very cool. Imagine that, a student who retains and replays their teachings. I think that that is what it is all about.” –artist, 2005

III. Reflections on Implementation

Our general observations of course outcomes are that the 2006 offering was not as successful as the two previous offerings. There appeared to be less harmony among the groups, and less commitment among both engineers and artists to the course. The following reflection about what differed between offerings explores this observation.

Individual Assignments: In 2004 and 2005, students started the term with individual assignments. This was changed in 2006 with the intent of allowing students to work with more partners before choosing groups for their final projects. In retrospect, the individual assignments may have played an important role in subsequent group dynamics. The Book Project allows the engineers to experiment with sculpture themselves, while at the same time reinforcing the time commitment required for a successful sculptural piece in both reflection and implementa-

tion (i.e., making good art is not “easy”). The individual version of Toy Hack assigned in 2005 created the equivalent opportunity for artists: they were allowed to experiment on their own with basic electronics in the context of a simple sculpture. As a result, the dynamic in later group projects appeared to be generally more fluid in 2004 and 2005, compared to 2006, with engineers contributing to creative aspects and artists participating in the technical implementation aspects. The result was greater group cohesion and a greater sense of collective ownership of projects.

Selection of Groups: In 2004, we approached group assignment with the goal of matching students with similar conceptual and aesthetic interests. The Book Project was used to evaluate individual students’ capabilities and aesthetic. The intent was to use the individual proposals for Freeing the Mind to pair students with similar interests. This was not as obvious as we had anticipated, except in a few cases where similar proposals were received. The result was that pairs were formed somewhat randomly, and were asked to combine their Freeing the Mind projects. This process was difficult in some groups. In some cases, neither partner wanted to compromise; in others, partners were unwilling to challenge each others’ ideas. It is expected that this latter phenomenon would become less of an issue if partners had longer to work together and get to know one another. A few students indicated their desire to change partners for the final project, and we decided to allow students to choose their final project groups, with the option of staying together. Again, this proved problematic when students were reluctant to disappoint their partners by saying they wanted to change. One student likened it to trying to end a relationship without hurting the partner. In the end, we took the students out to the local pub and didn’t let them leave until the groups were finalized.

In 2005, the two individual projects at the beginning and a class field trip to visit Toronto galleries provided ample opportunity for students to assess each other. We considered asking students to choose their own groups, but based on the experience with the final project in 2004, decided against it. We used the same mechanism as in 2004 to create the initial groups, based on our assessment of the initial projects and the Freeing the Mind proposals. In 2005, however, we decided to keep students in the same groups for the final project. The quality of the final projects was quite high, and we got little negative feedback from groups on their collaborations.

In 2006, we approached group assignment with the philosophy that the collaborative experience would be richer for having worked with as many different partners as possible. Individual assignments were dropped, and each student worked with 3-4 different students from the other discipline over the course of the term. As might be expected, this approach meant that final group partners had for the most part not worked together before. This may be one reason that final project concepts seemed to take longer to finalize in 2006, resulting in less finished work by the end of term. It was reflected in the apparently level of comfort and commitment within the groups.

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As a general conclusion, it would appear that depth of experience with consistent partners provides for a more successful collaborative experience than breadth of experience with different partners. While it is difficult to discount the effects of varying personality and individual commitment, it would appear that maintaining group assignments across projects leads to a more complete experience and allows for more significant interaction of the type the course is designed to provide.

Cross-Disciplinary Learning Study

To formalize some of these anecdotal observations, and potentially help generalize them to other cross-disciplinary experiences, we have designed a study which looks at feedback from students on their conceptual development and collaborative learning experiences throughout the course. We take a multi-methods approach using student-compiled online design journals and open-ended discussion sessions. The pilot for this study was run in Winter 2006.

Design Journals: Students maintained their design journals on Tablet PCs on loan from the university, and submitted them weekly in UW-ACE, Waterloo’s online course management system. The goal of the design journals is to document the design process and make notes related to their collaboration and their specific projects. In addition, students were asked to respond, in their journals, to two guiding questions weekly. These questions were specifically chosen to probe issues related to cross-disciplinary learning.

Discussion Sessions: Discussion sessions were held three times during the design stages of the final six-week project. The sessions were interactive group “workshops,” where students were encouraged to provide critical feedback on their peers’ designs, as well as sharing their experiences about collaboration, sculpture and design, etc. These sessions were recorded by a research associate.

These data have now been collected, and students’ design journal reflections and transcripts from the discussion sessions will be analyzed for a deeper understanding of the learning experience and what it has meant to them personally. We will be looking for information on what the cross-disciplinary learning experience meant to the student, students’ own conceptual development, and its impact on artistic and practical learning experience meant to the student, students’ own conceptual development, and its impact on artistic and practical applications as applied to the joint creation of the integrated system. The goal of the design journals is to document the design process and make notes related to their collaboration and their specific projects. In addition, students were asked to respond, in their journals, to two guiding questions weekly. These questions were specifically chosen to probe issues related to cross-disciplinary learning.

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We expect common themes to emerge from this qualitative analysis. Based on anecdotal evidence from past offerings, we expect that students will report positively on the learning aspect and impact of the course. Part of the goal of this research will be to determine what makes for this positive student experience and effective transformative learning process, and to see whether the conclusions can be generalized into a model for effective cross-disciplinary learning in other settings.

Summary

This paper has described a unique inter-disciplinary course developed at the University of Waterloo, FINE392: Technology Art Studio. The collaboration between engineering and sculpture students in the context of the course projects provides unique opportunities for transformative learning of cross-disciplinary methods for creative design and problem solving. Anecdotal evidence from the three annual offerings to date (2004-2006) suggest that both engineering and fine arts students, working together, become adept at integrating their respective knowledge backgrounds to produce unique sculptural art forms. Generally, we observe that the quality of work improves from project to project, as long as the partners continue to work together, suggesting this knowledge integration is related to interaction between partners. Further, we have observed that strong cross-disciplinary interests develop over the span of the course and, in some cases, become integrated into students’ future study plans.

On graduation in 2004, one engineer registered in a qualifying year for the University of Waterloo’s MFA program. Another, who graduated in 2005, is attending NYU’s Interactive Telecommunications Program (ITP) in the Tisch School of the Arts. Neither had considered anything other than a career as an engineer before taking FINE392. Also, from each of the 2004 and 2005 classes, at least one of the artists has developed a strong interest in technology-mediated art and is continuing in that direction in her practice.

A scientific study has been undertaken to assess the extent and mechanisms of cross-disciplinary learning in the context of the course, with the hope of generalizing these results to suggest effective course models for this and other cross-disciplinary experiences. Preliminary results of the pilot run in Winter 2006 should be available by the fall.

References