A General Education Course in Tangible Interaction Design

Fred G. Martin
Computer Science Department
University of Massachusetts Lowell
Lowell, MA 01854 USA
+1 978 934 1964
fredm@cs.uml.edu

Karen E. Roehr
Art Department
University of Massachusetts Lowell
Lowell, MA 01854 USA
+1 978 934 3586
karen_roehr@uml.edu

ABSTRACT
The authors created a general education undergraduate course, *Tangible Interaction Design*. We describe our learning goals, the course structure, “Tiddles” (in-class exercises that promote creativity), and three student final projects. The paper contributes to the literature on teaching interaction design by describing what’s achievable with undergraduates at a public university in a general education context.

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arts, computing, sensors, creativity, tangible interaction

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General Terms
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INTRODUCTION
“Tangible Interaction Design” is part of a larger initiative at our university to create connections between computing and the arts. Prior to this, our team developed a general education course combining computer science, robotics, and art [10]. Others combined computer science and music [2] and computer science and web art [3].

In developing our course, we combined our expertise in robotics education (Martin) and graphic design (Roehr). We wished to appeal to undergraduates across our university—e.g., majors in engineering, science, humanities, visual art, and other disciplines.

In this paper, we present our course structure, including the core assignments and weekly, in-class creativity exercises. We then describe three student final projects. In the discussion that follows, we make connections with the work of others teaching interaction design, and analyze the results. But first—a vignette:

A woman stands before a row of small vertical copper bars waving her hands in between them. Sounds fill the space and lights flash simultaneously from a Plexiglas box below. Intrigued, she continues making gestures, her whole arm involved as the sounds emanate faster and louder. Soon another person joins her and together they create a percussive pattern accompanied by a light show as though they were performing at a concert. Both people are interacting with piece titled “Intangible Music,” a student project integrating embedded computing and interaction design. The student duo that created the piece stands quietly to one side clearly delighted, as they watch people interact with their project.

COURSE DESIGN
“Tangible Interaction Design” was offered in the Fall 2008 semester, meeting twice a week for 75 minutes per class. To encourage student registration, and further emphasize the art/computer science collaborative nature of the course, we obtained dual general education approval for the course. It satisfied a required science/technical distribution for liberal arts majors, or arts/humanities distribution for science and engineering majors. We attracted 24 students, with an equal number in the two areas.

The course had three major components: (1) A series of 5 core assignments and weekly, in-class creativity-enhancing exercises, dubbed “Tiddles,” and (3) a final team project, which was exhibited in one of two local partner museums.

Lab and Materials
Although we had a physical lab, we lacked a dedicated lab time slot. Many of our students are commuters, and it is challenging for them to find time outside of class to meet. We shared lecture time with working in the lab, particularly in the second half of the course as the final project commenced. We also used lecture time for presentations and critiques of student work. In this way, we strove for the studio culture that is common in art and architecture practice, as well as the engineering/science laboratory [1].

We selected specific materials and technologies for the students to use in their work. This was done to keep things manageable for this diverse group, many of whom had minimal experience with computational and art media. Some of our students had never uploaded a digital image to the web. In their final project, most students did choose to
work with the materials and technologies that were introduced.

**Assignments**

In five core assignments, we made an explicit connection between the physical, the creative, and the computational, with a focus on interaction. We introduced a number of digital technologies, which would serve as the “tangible tools” for the final project.

**Assignment 1.** The course began with a discussion of functional design, and what constitutes good design and poorly designed objects. Students read part of Donald Norman’s book *The Design of Everyday Things* [7]. In first assignment, students analyzed the functionality of objects in their daily lives. With principles such as mappings and visibility, students easily found poorly designed doors that were confusing to open, and well designed appliances with obvious, 1-button interfaces.

Students were required to post their findings as a photo-essay on a public course wiki. While current student culture embraces the web for social sites like Facebook, the idea of making one’s work available for public viewing was was disconcerting to some. For art students, this was common practice. Others felt a mixture of excitement and apprehension. We reviewed student work as a group in class, introducing students to the practice of constructive critique, common in the arts community.

**Assignment 2.** In the second assignment, we introduced software interfaces. Using MIT Scratch software, students created screen-based interactive projects and published them on the Scratch web site.

This assignment had two intentions: (1) to have students apply Norman’s design principles to a software interface, and (2) introduce students to programming in Scratch (which would be used in the final project). Norman’s work focuses on everyday, physical artifacts, and most students did not understand the assignment intention. The majority created a simple videogame, inspired by the large library of projects contributed by the Scratch community. We plan to redesign this assignment in our subsequent course offering.

**Assignments 3 and 4.** In the next two assignments, students worked with paper, cardboard and plastic. They applied craft skills first, and then transitioned to computer-aided design. They created cardboard templates for a box-like game arena, followed by a cardboard character prototype inspired by an action verb such as “dance.” Students returned to the computer and used vector-based software to re-draw their character, and produced it in acrylic using a laser cutter. They published their CAD designs with photos of the finished characters on the personal manufacturing web site, ponoko.com.

Most students created designs that directly translated from cardboard to plastic. In these, use of mechanism was simple—e.g., parts rotating around drilled holes and held together with clips. A few students attempted more challenging designs. One of these was an articulated accordion-like snake. In the cardboard version, each link of the snake had an elegant joint that made use of the partial flexibility of the material. When the student attempted the acrylic implementation, he realized that a fundamental redesign was required. The links did not bend as they had with the cardboard, thus he developed a different hinge for the acrylic links. We all agreed afterward that the cardboard prototype was a more interesting piece as the snake lost its slink-like mobility in acrylic.

Use of the Ponoko site opened up discussion on the issue of intellectual property. Ponoko allows its users to stipulate any of several licenses for their published work, along the range from a closed design (customers may order manufactured instances of a design, but never receive the source CAD drawings) to licenses that request attribution but welcome sharing and remixing, to public domain. Both faculty members were able to speak to this issue from the perspectives of their different disciplines.

**Assignment 5.** For this project students explicitly connected the physical to the virtual using the Scratch PicoBoard, which interfaces light, sound, and touch sensors in the physical world to the animated screen world. Each had to design a screen display that was synchronized, triggered, or otherwise coordinated with the body movement and implement their idea using a PicoBoard and MIT Scratch software. These too, were posted on the wiki and tested in class.

Students’ work on this assignment ended up getting blended into the final project work; in a subsequent offering of the class, we plan to introduce Scratch and the PicoBoard together as an earlier assignment.

**Tiddles**

These weekly exercises usually required working with familiar materials—LEGO bricks, paper, Play-Doh, and paperclips. A few Tiddles were creative writing exercises. For 15 minutes during the lecture period, students were “free to have fun, to play, and to make things,” as one said in the final class. In the opening class, students were instructed to make a paper airplane and fly it to the front of the class. Other Tiddles (shown above) included building a bridge between two desks, making the tallest tower, and “making an object with pretend magical powers.”
Some Tiddles (e.g., bridge- and tower-building) involved real engineering. Others were pure fantasy, like the object with pretend “magical powers,” which generated models such as a purse with an endless supply of cash, strap on wings for transportation, and a remote that allowed good experiences to be repeated at will.

Two insights emerged from this work: (1) students’ ideas flowed more freely when they made physical models than some other paper-and-pencil brainstorming exercises. We noticed this most clearly in the “magical object” exercise. We had tried a writing assignment prior to this challenge. The “hands-on” Tiddle immediately engaged the students, as they each made models of their ideas, and then presented to the class afterward. (2) Tiddles that involved real engineering allowed us to engage in discussions about aesthetic vs. functional design. Broadly, the Tiddles supported a welcome playfulness in the classroom, and facilitated good sharing and discussion.

Final Projects
In the course final project, students were expected to integrate the technology and design tools we had introduced. Working in teams, they developed an exhibit for one of our partner museums——The Revolving Museum, a contemporary art museum in Lowell, MA, and the Children’s Discovery Museums in Acton, MA.

Students produced 10 unique projects. Of these, 8 made use of the Scratch/PicoBoard materials, and 3 made use of the laser cutter (1 used both). Three projects are described here, to represent the range of work in the class.

Scooby—A Physical/Virtual Puppy
Scooby, developed by two liberal arts majors, is a physical and virtual puppy dog. Using a plush puppy, the students carefully installed large arcade-game buttons as the dog’s nose and on its two front paw-pads, and then wired the three buttons to their PicoBoard interface. They created an on-screen representation of the dog with the Scratch software. The virtual puppy is displayed on a netbook inside the plush doghouse, behind the physical puppy. By pressing any of the physical puppy’s three buttons, the on-screen puppy reacts. The project had an immersive, dollhouse appeal, especially for small children.

In their initial design drawings, the two students had planned to make a flat profile of the puppy using the laser cutter and acrylic plastic. Partly because of the difficulty of doing this, and partly because the idea didn’t appeal strongly to them, they instead shopped at a craft store for the plush materials—leading to a much more engaging final product.

Soccer Scratch—An Arcade-Style Video Game
Soccer Scratch was created by a philosophy major and a psychology major. It was a simple videogame with a visually appealing physical interface. To shoot the ball at the on-screen goalie, one kicked the wall-mounted soccer ball. In the students’ design process, they selected a sports theme and narrowed it to soccer, but had a breakthrough in their design when they changed their early software prototype from a side-view of the soccer field to that of the shooter’s view of the goal itself. Then, the physical action of kicking the ball became kinesthetically integrated with the virtual action.

Intangible Music—Analog and Computational Theremin
Developed by two engineering majors, Intangible Music is a two-person musical instrument that combines an analog Theremin and a computerized drum machine. Break-beam light sensors trigger the drum sounds, and accompanying visual displays are shown on a computer monitor hidden underneath the tabletop. The exhibit allows two people to collaborate in creating music, while attracting attention from others in the same shared space.

DISCUSSION
The authors come from different disciplines, but we share teaching styles. We were both were comfortable “being a student” for the other—e.g., genuinely asking questions of each other in front of the entire class. In this way, we created a context of trust and respect for the other’s knowledge.

It was challenging to create clear and fair rubrics for evaluation and grading. For each of the assignments, we developed a check-list of project deliverables, and most of
the grade was based on students merely completing them satisfactorily. For example, in the laser-cut character assignment, the deliverables were the character itself, the Ponoko project page, EPS artwork, and a photograph. Students were given opportunities to resubmit their work if they wished a higher grade. However, we also considered the creativity of the piece itself and how well it was made. Klemmer et al. also discuss the challenge of grading in the context of student interaction design projects [4].

We were conflicted when evaluating student final papers. Students had devoted so much work to creating their “high-fidelity prototype,” that it was questionable to hold them to the usual writing standards. In a typical gen-ed class, the writing would be the product. In our class, the prototype was the product, and the writing explained the process. We compromised by assigning grades to the papers based on college standards, but then giving the papers a relatively small weight in determining the final course grade.

We tried to impose a design brief followed by rigorous project proposal process, but were only partially successful. As Sas and Dix describe, there is a “tension between ambiguity and structure” in the problem specification and solution process [8]. For many students, the act of developing the prototype (and modifying it along the way) was an essential part of the process. These students didn’t have a strong sense of their own creative capabilities, as their work with all of the digital media was so new. Intangible Music was an exception to this—these students knew what they could accomplish from the outset. This was not true of most students, however. Scooby and Soccer Scratch were more typical: projects that underwent substantial changes from conception to inception.

CONCLUSION

The class attracted students from more than 10 different majors. All had an opportunity for creative expression using computational tools and the in-class Tiddles exercises. Students stretched themselves in new directions: those in technical majors learned about design and communication, and those in liberal arts majors learned how to use sensors and programming to achieve a design intent.

Final class comments ranged from one student who “loved” the course and wants to study the next level to a student who struggled and could not see any relevance in the assignments until completion of the final project where the student had an epiphany. Many claimed they developed an awareness of how they interact with objects and the quality of how these “things” work or fail.

Students appreciated the range of materials and tools we introduced. They enjoyed working with each other, and collectively represented a wide diversity of backgrounds. In the future, we plan to give stronger emphasis to graphic design, design process and art in the course as requested by the students.

EPILOGUE

Of all the projects, Intangible Music was most engaging. It will join the music section in the Acton Children’s Discovery Museum. Museum visitors (both children and adults) will have the opportunity to interact with this piece, to make sounds, set off lights and create joyful noise.

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