**iDesign Studio: Gateway to Innovation and Entrepreneurship via Incubation Curriculum**

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**ABSTRACT**

The iDesign Studio course was developed and taught as a first year seminar at Mount Holyoke College, pitched to attract students that did not perceive themselves as “techies” or “entrepreneurs.” It has quickly gained popularity as students discover hands-on content that demystifies tech and empowers them to make creative projects, such as motion-dependent twinkling ballet skirts and tech-infused children’s books. For many, the course provides an unexpected gateway to the makerspace on campus, a place where innovation and entrepreneurship are cultivated. In this paper, we present the iDesign Studio curriculum, which introduces making with electronics and microcontrollers through an incubator experience. Course modularity has led to adaptations for different audiences, including hour-long workshops for primary-schoolers.

**INTRODUCTION**

The iDesign Studio curriculum creates an incubator experience through hands-on activities and a supportive climate, enabling students to step outside their comfort zone and discover unexpected pathways. The course is infused with the entrepreneurial spirit, highlighting a need for students to develop a propensity for risk-taking [1]. We follow the work within entrepreneurship education [2] and makerspace education [3], as well as constructionism more generally [4,5], by suggesting that risk-taking can be cultivated when students explore, play with and test ideas in a makerspace; supportive scaffolding leads to incremental risks as confidence is developed.

Weekly modules during the first half demystify technology by introducing the basics of electronics and microcontrollers, each with a laboratory exercise designed to kick off an accompanying assignment that inspires innovation. The remainder of the semester is spent pitching and developing original technical projects; entrepreneurial lessons that were implicit in the modules become explicit through elevator pitches and a timeline with deliverable milestones. A strong support structure with studio time, near-peer mentors and a shared space that facilitates camaraderie is influenced by the social cognitive theory that emphasizes the role of feedback in the development of self-efficacy and how self-efficacy can drive persistence in the face of failure [6].

A. HISTORY

In 2013, iDesign Studio was taught as a first year seminar at Mount Holyoke College, a women’s liberal arts institution. The course has been offered 5 more times (no longer restricted to first years), once as a grant-funded 3-week summer adaptation with scholarships for community college women. With a limited class size of about 15 seats, it is taught in the makerspace on campus and attracts students from a variety of backgrounds and disciplines. For many, the course is an introduction to the makerspace and a gateway to connected programming on campus, including entrepreneurial activities [7]. The course’s popularity is evidenced by a consistent waitlist each semester.

B. THE ROLE OF MAKING, INNOVATION AND ENTREPRENEURSHIP

The course uses an incubator approach to support experiential learning and design thinking within a makerspace [8]. Assigned work contains enough scaffolding to provide structure while leaving plenty of room for innovation, and studio time is spent in a makerspace with the availability of the instructor, near-peer mentors, hardware components and prototyping equipment. Our choice to build this incubator experience around the creation of tangible prototypes was influenced by Papert’s (1980) constructionist theory [4], which emphasizes the power of making artifacts as a way to propel self-directed learning, and by the crucial role the learning environment plays in understanding and forming the learner’s experience [5].

Entrepreneurial thinking is supported throughout the course, as projects implicitly mimic the business cycle from ideation to prototyping constrained by available resources. The hands-on, creative nature of the work incorporates risk-taking and recovery from failure throughout the design, implementation and revision phases [9]. Entrepreneurship education often focuses on cultivating certain attributes or mind-sets such as questioning the status quo, persistence, and identifying novel markets or processes [2]. Explicit requirements, such as a 90-second elevator pitch and design document, help students think carefully about their final project, while more informal activities, such as in-class discussions around current products and acquisition of hardware components, encourage students to consider market and resource implications.

Student innovation is infused throughout the course, as assigned work incorporates creativity at the outset. For example, a module on using a microcontroller to play simple tones is paired with a weeklong assignment to build a “music box”: a physical housing using a photosensor to detect light and responding by playing a tune. Student projects ranged from a simple gift bag that played “Happy Birthday” when it was opened to a puppet that “sang” when its mouth was opened. Giving students ownership of the ideas and subsequent design work encourages initiative, persistence, and risk-taking [3],...
as most used personal or community interests as inspiration [10].

C. A GATEWAY TO COMMUNITY AND UNEXPECTED PATHWAYS

The course is pitched to attract students that might not label themselves as “techie” or “entrepreneurs.” By starting at a common ground with no assumed background or experience, we can use the incubator experience to build a strong sense of community. Studio time is spent in a makerspace alongside selected near-peer mentors [11]; we are careful to create an inclusive and welcoming climate environment. A maker classroom can inspire students to take risks with their learning, but such risk-taking, from taking on more difficult tasks to recovering from failure, can be impeded by fear of negative criticism [12]. Furthermore, when self-efficacy in technology is not yet solidified, students will tend to avoid challenge and practice, without an environment (or staffing within) intentionally trying to counteract this [13].

We strive to create a space where students, mentors and the instructor experience successes and failures together; these moments often provide comedic relief, such as the repetition of a single sound bite exposing a software bug, and subsequent community building. Paired with hands-on material, the resulting incubator approach empowers many students to consider unexpected pathways [14,15]. Indeed, four of the fourteen women who took the first offering went on to complete computer science majors.

COURSE STRUCTURE

The course is structured so that students experience the process and resources similar to what would be found in a startup incubator. The first half of the curriculum is built around hands-on laboratory activities that introduce the basics of electronics and microcontrollers while independent assignments emphasize individual creativity. The remainder of the course is dedicated to a final project that encourages students to bring innovative ideas to life, with entrepreneurship incorporated implicitly and explicitly throughout the process. Embedding the course in the makerspace on campus provides access to equipment and a flexible space that encourages collaboration and innovation.

A. LOGISTICS

Timing. The course meets twice each week, with a “lecture” slot of 75 minutes and a longer studio slot of around 3 hours. By meeting in the makerspace on campus, class time can be used flexibly, allowing a mix of short lectures, discussions and hands-on laboratory work.

Staffing. In addition to the faculty instructor, the course is supported by two student teaching assistants, who offer around 10 hours a week of evening drop-in help sessions and are also present for some of the class meeting times. These teaching assistants are generally chosen from the pool of previous iDesign graduates. Training and support includes a start of semester discussion and weekly 30-minute check-ins. Supplementary training for specific laboratory activities is scheduled for new labs; the instructor typically walks through the planned activity with the TAs. As near-peers, the TAs are also crucial in communicating student workload and perspectives to the instructor.

Space, equipment and tools. The makerspace offers an array of equipment and a flexible space that enables student innovation. These include:

- Desktop computer stations maintained by college technology services with software for accessing online course materials (e.g., Arduino IDE, Adobe Design Suite).
- Electronics prototyping benches with multimeters, battery supplies, discrete components, spare kits, soldering irons, consumable solder stock.
- Tool cart with measuring tools, marking tools, cutting tools, gripping tools, drivers, drills, sanding and grinding consumables.
- Sewing table with needles, thread, fabric cutters, cutting mats, and four sewing machines.
- 2D fabrication via laser cutter, vinyl cutter, large format printer. Off-cut materials from previous projects are stored and available for student use.
- 3D fabrication via additive-3D printer, vacuum former, and tabletop CNC mill.

In general, equipment has dedicated space to facilitate ease of transition between activities. For example, soldering simply requires turning on the soldering iron and getting right to work; there is no need to take the irons off the shelf, find helping hands or track down consumables. A fast-start soldering iron facilitates minimal delay between beginning the activity and melting metal in an effort to support a 30-second soldering repair actually taking 30 seconds. Other examples include dedicated computers for the laser cutter, CNC, printers and enough desktop computers for each student to work independently. Large reconfigurable tables support diverse activities in lecture and studio sessions.

In addition to the shared resources, the makerspace includes dedicated storage for iDesign Studio:

- A project storage rack allocates each student a plastic lunch tray measuring approximately 16”x20” for storage; this lunch tray rack is mounted on casters to facilitate movement between teaching areas and storage areas.
- A multi-bin cabinet organizes consumables.
- Bins for modular activities contain complete sets of components necessary for specific hands-on activities.

Materials and supplies. Inventory for the course is bought and maintained by the staff. Students are provided materials for weekly laboratory exercises and stock is available for associated assignments; whenever possible, supplies are reused across multiple modules. We note the incorporation of the Arduino-compatible SquareWear wearable computing platform by RaysHobby.net (shown in Fig. 1), which was partially designed for the iDesign Studio course. This platform includes on-board components, such as light and temperature sensors and a buzzer, lowering the overhead for initial projects (e.g., the “music box” mentioned in the Introduction).
B. CURRICULUM

Introductory modules. Weekly modules during the first half of the course provide an introduction to the basics of electronics and microcontrollers as well as core components of the design process. Each of these modules is loosely structured as follows:

- a short lecture on technical material
- a hands-on laboratory activity
- an assigned project with technical requirements and room for individual creativity

This schedule is structured to encourage experiential learning cycle. In the lecture, students are introduced to new concepts and asked to consider how to utilize them. This is followed by studio time, where students are given a hands-on laboratory exercise and support to work with the new technologies and try out different configurations. The out-of-class project generates concrete experiences with bounded endpoints. Finally, the weekly cycle concludes with a show-and-tell period of student-led reflective observation and discussion.

Final project. The remainder of the course is dedicated to a final project, where students are guided through a design process mimicking a startup incubator process. The entrepreneurial lessons of communication, market context and obtaining required resources infused throughout the introductory modules are made more explicit as students kick off their projects with a 90-second elevator pitch and design document. The design cycle continues through prototyping, ordering parts, refinement, documentation, presentation and reporting. Students present progress weekly through oral presentations and online documentation. Deliverables include pitch documents, update posts, presentation slides, design documentation reports and the physical artifacts.

Grading policy. iDesign Studio is primarily focused on building self-efficacy and excitement among liberal arts students, and the grading policy reflects that. This single-minded focus is possible in part because iDesign Studio is not currently a prerequisite for any other course. To help emphasize that exploration and persistence through failure will be rewarded, students are told that attendance and participation are weighted more than more traditional academic ambitions like exams and quizzes. In general, we found that students were inspired to go far beyond the minimum.

HIGHLIGHTS AND IMPACT

The incubation curriculum is deliberately constructed to create space for innovation while providing the technical foundation and support required to bring ideas to fruition. Students combine, extend and modify what they learn in smaller projects as they work toward their final projects. We describe sample trajectories through the curriculum that highlight how powerful the experience can be for students, including those without a technical background.

A. INTRODUCTORY MODULES

The introductory modules give the foundation for learning new technology; this includes specific technical material as well as the more general experience of reading documentation and working through sample code. We provide a glimpse into the structure of a weekly module by describing the Storytelling module.

This module kicks off with a class discussion about storytelling and what the minimal requirements for communication could be. The instructor asks the students if they think that they could tell a story with only two lights and challenges them to design a script for a short love-story where the two lights represent star-crossed lovers. A typical script follows: the stage opens with no lights, first light appears, second light appears, lights blink on-and-off in harmony, the second light ceases to light, and scene ends when the first light extinguishes. Students initially find this silly, but quickly name the characters and are crushed when the characters expire.

The hands-on laboratory requires the class to convert the script into an interactive light display. Students draw circuit and wiring diagrams for the two-LED circuit using skills developed the previous week. The instructor introduces lines of code for turning LEDs on, turning LEDs off, delaying for one second. The students practice using these three lines of code in different configurations to animate the script with a Square-
Wear and lights. The lecture is concluded with a “peer-programming” activity, where the students guide the instructor through completing the program; the instructor follows the class’ directions and poses questions if the program does not behave as intended.

The storytelling weekly project requires students to create a program with four 10-second stories that are activated by the button, output to at least one external LED (in addition to the SquareWear internal LED), schematic and wiring diagrams and photographic documentation. A sample student submission can be seen in Fig. 3. Students are also expected to explain and perform their story in front of the class as part of the weekly show-and-tell.

B. FINAL PROJECTS

Students kick off their final projects with a 90-second elevator pitch. The pitch requires them to think of an audience for their “product,” and many find inspiration in personal interests and experiences. We give several examples to highlight the breadth of completed projects; refer also to Figs. 4 and 5.

Motivated to make reading more exciting, a kindergarten teacher’s daughter wrote, illustrated and hand-bound a book about a Shy Chameleon whose color changes page to page. An intended music major created Music Touch, canvas sheet music that plays the name of a note in its pitch when touched; the course inspired her to complete a computer science major and start HackHolyoke, a hackathon with the goal of being inclusive and achieving gender parity. WordBoard with flashing LEDs that reward correct matching of English and Spanish word cards was developed by a mother to help her children learn both languages. A student wanting to invent a new slippers with LEDs and a vibrating mini motor disc that buzzed when close to obstacles; the following semester, she won “Audience Favorite” at the pitch competition on campus and presented her product at a regional entrepreneurship exhibition.

The Split-Brain Neurological Simulator demonstrates how an affected individual can process visual information, but not see it. This project, led by a biology major, included custom interfaces to an existing neuron simulator with the addition of light sensing and motion capabilities. The Musical Theater Diorama was designed by a student double majoring in Architectural Studies and Theatre Arts. The diorama has interchangeable sets that trigger light and sound corresponding to the appropriate scene. Originally pitched by a dancer to help teachers and students monitor precise poses, Accellexpression is a motion-dependent ballet skirt with color-changing LEDs.

The course has also inspired a new interdisciplinary collaboration between iDesign Studio and a costume design class for an Underwater Community performance. Costuming and iDesign students formed paired teams (one student from each course) to facilitate a greater understanding of technology for costuming students and motivate aesthetic aspiration for iDesign students. Teams created full-body costumes that expressed a shared underwater creature aesthetic using translucent fabric materials, LED light strips, the SquareWear platform and interactive light sensing.

AVAILABLE CURRICULAR MATERIALS

All course materials for iDesign Studio are available online and can be found on the Mount Holyoke Makerspace website (https://commons.mtholyoke.edu/makerspace) under course offerings. Provided materials include course syllabi, lab instructions, calendars and links to past student blogs. The Makerspace website also provides additional information about workshops and facilities available to the courses.

Due to its modular nature, parts of the iDesign Studio curriculum have been adapted for a variety of audiences and time durations. These adoptions can be found at https://hes ter.mtholyoke.edu/idesign/idesignHome.html. This dedicated iDesign Studio website features a Getting Started section that allows educators to build a base curriculum depending on the learning level and needs of their student body. The curriculum can further be customized by swapping out or in modules and assignments found under Educator Resources. Pre-designed
and carted kits allow for quick and easy purchases for all iDesign modules, assignments and workshops.

CONCLUSIONS AND FUTURE WORK

The iDesign Studio curriculum has provided an unexpected gateway to innovation and entrepreneurship for a number of students. By embedding the class in our makerspace and deliberately constructing scaffolding to provide an incubator experience, the comprehensive experience unleashes risk-taking and creativity while building persistence and confidence.

Most of the students who have taken the course entered with the perception that they were tech novices and were surprised by how well they mastered the initial projects. Indeed, it seems that their low self-efficacy could actually be leveraged to encourage risk-taking, as they expected to encounter challenges from the start. The inevitable cycle of failure, analysis and recovery, whether technical or design-related, built their confidence and encouraged persistence through the next stumbling block. As a result, they were more open to conceive of increasingly ambitious projects as the weeks progress, thereby boosting their self-efficacy. The quality of the student projects and the interdisciplinary nature of their interests and future pathways speaks to the power of our approach.

Future directions. In the future, we are eager to unpack the longer-term trajectories of students, ways some of the lessons can find their way into other introductory courses or first year seminars, and how specifically entrepreneurship may be an interdisciplinary hook for students coming together as a diverse learning incubator that is not owned by STEM alone. The approach has the potential to fuel new initiatives across the sciences, social sciences and humanities.

REFERENCES


