Empowering the Liberal Arts Student: Tech for All

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ABSTRACT

A liberal arts education at Mount Holyoke College prepares students for "purposeful engagement" in the world. A makerspace offers the possibility of injecting hands-on activities into the curriculum in a novel way that can provide empowering applied experiences for all. While entering students generally embrace the breadth of education that a liberal arts college offers, many who enter are tech-phobic, would never consider pursuing a degree that requires computer coding or regular quantitative analysis, and have limited or no hands-on experience building things. Our goal is to increase the general technical and mechanical literacy of our students while inspiring some to pursue technical fields in which women are severely underrepresented. Our size makes it easier for faculty to work across disciplines, and we have been growing the "maker culture" for the past two years as we plan a 5,000 sq ft makerspace. Our size also presents challenges due to small numbers, and we are developing best practices that work for our size and student body. We do not have the engineering majors that often dominate – and staff – these spaces. We can easily provide role models that do not fit the typical "maker" stereotype through near-peer student mentors, diverse faculty and staff, and alums. We provide both curricular and co-curricular opportunities that draw in students with backgrounds who would not intentionally sign up for activities labelled "computer science" or "engineering". These experiences can spark an initial interest that changes their course choices in subsequent years. By locating the future makerspace in a dormitory and consciously creating a discipline-neutral atmosphere, we can provide access to empowering experiences that are open to all. In this paper, we describe our efforts to cultivate an inclusive makerspace environment with activities that can transform students' perceptions of technology.

INTRODUCTION

The major global challenges of the 21st century have a scientific or technical component, but they will not have purely technical solutions. Collaborative teams must have a breadth of expertise across disciplines to tackle complex problems. A liberal arts education prepares students to be critical thinkers with the skills to have meaningful impact on their communities. While many will not pursue STEM-based endeavors, students need to be technically literate with the confidence to interact with unfamiliar technical areas. A makerspace embedded in the liberal arts has can infuse technical experiences across campus, through curricular and co-curricular programming. We present the efforts underway at Mount Holyoke College (MHC), a women's liberal arts college. With a focus on fostering interdisciplinary collaboration and an inclusive climate, the 2-year-old makerspace is quickly becoming a place where students discover that technology does not have to be intimidating and sequestered.

To place the challenges and opportunities of a makerspace at a liberal arts institution like ours in context, it helps to understand Mount Holyoke's incoming student population. MHC is uniquely positioned to attract a wide range of traditionally underrepresented students into experiences with technology. The student body is approximately one quarter international, one quarter domestic minority, and one quarter first generation. A survey of incoming students asks them to rate how interested they are in taking courses in a range of fields, with results shown in Fig. 1. 75% of our incoming students report they are uninterested or wish to avoid engineering courses, and 51% feel this way towards mathematics, statistics, and computer science [1]. Students express the most interest in foreign languages and literature, social sciences, and English languages and literature.

Women regularly receive the message that programming, engineering, computers, and technology are a white, heterosexual, male domain, along with fields like construction, auto mechanics, and machining. Women are not encouraged to tinker, to get dirty, or to take apart the computer. While using a wrench is not quite the liberal arts ideal, we all live in a physical world, and women generally have had fewer opportunities to develop their mechanical and spatial reasoning. A lack of experience with the mechanical world can lead to feeling out of place in early engineering courses, in science labs, and in spaces like a makerspace [4, 5, 6]. Nationally, women continue to be severely underrepresented in computer science, engineering, and physics at the bachelor's degree

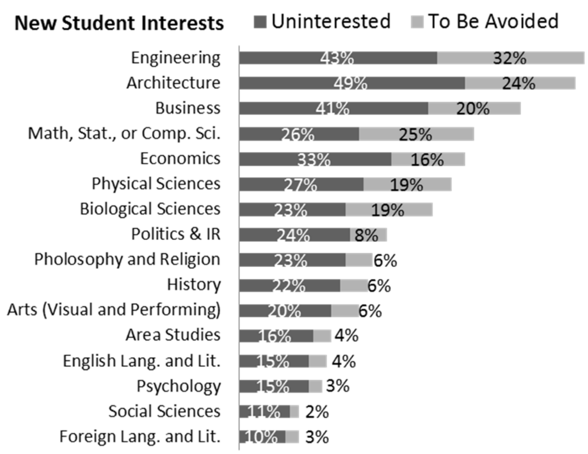

Figure 1 Results from the New Student Survey, 2010 - 2015 Students rank their interest in taking courses in different fields, selecting among "Very Interested", "Interested", "Uninterested" and "To Be Avoided".

level [2]. Despite this, Mount Holyoke graduates more female computer science and physics majors than schools ten times our size [3]. Providing role models has been a key to the successful growth and support of diverse participants within male-dominated fields, and we continue this strategy through near-peer student mentors, diverse faculty and staff, and alums that do not fit the typical "maker" stereotype. While all of our students are considered members of a demographic that is underrepresented in STEM fields – as women, transgender, or genderqueer individuals – our goals extend beyond gender diversity to include racial, ethnic, economic, geographic, etc.. We do not presently track these data. We do monitor the diversity of the majors that we reach through our events as we tackle general technical literacy and seek to attract new students into STEM majors.

The first concrete step towards broadening participation in "maker" technologies occurred in 2013 with the creation of a course we call iDesign Studio. With the explicit goal of introducing programming, hardware, and design to students with little interest in pursuing a STEM major, the first year seminar enrolled students seeking to satisfy the science distribution requirement. The curriculum aims to demystify technology and teaches electronics using Arduino compatible SquareWear [7]. For more information, see [8]. In this first year cohort, four of the fourteen students became computer science majors. One of these students founded HackHolyoke [9], a regional hackathon that is entirely student run and achieves gender parity among the participants.

The initial success with iDesign Studio led to grant funding to run the class for community college students in the summer of 2015. Instead of running the course again in a traditional computer science lab, the college provided funding to reconfigure our Media Lab in the Art building and to purchase a laser cutter. Significantly, the college committed to funding a full time coordinator to develop programming and support the space along with student workers from Library, Information, and Technology Services (LITS) who previously staffed the space as a digital media lab. This shared space is our present makerspace. It now contains a laser cutter, two 3D printers, an Other Mill, a vacuum former, a vinyl cutter, and a sewing machine, along with tools and supplies for digital and analog electronics and basic hand tools. Additional spaces on campus provide specialized equipment for "making" that can meet needs as they arise. The scene shop (mostly woodworking) can be accessed by students working on theater productions; the costume shop is used by students enrolled in a class or working on a theater production; the sculpture studio is used by studio art students; the science machine shop is closed to students. Conveniently, the sculpture studio is just one floor above the present makerspace.

Critically, faculty and staff lead the makerspace initiative at MHC, explicitly working across disciplines from the outset and cognizant of the need to find creative ways to expose our diverse student body to technology experiences. Our small community of about 200 faculty leads to frequent conversations across disciplinary boundaries; we do not suffer from the typical disciplinary silos where the physics professors rarely interact with chemistry, let alone English. This familiarity led to quick collaboration across the spaces with relevant equipment, and to a diverse group of faculty discussing the vision of the future space. A formal faculty and staff seminar in 2015-2016 academic year included professors from psychology and education, English, economics, and international relations, who together articulated a vision and advocated for establishing a larger makerspace in a discipline neutral location. The college is presently converting the kitchen and dining hall of a residence hall into a discipline-neutral 5,000 square foot makerspace.

ENGAGING DIVERSE STUDENTS AND FACULTY AT MOUNT HOLYOKE

As an academic makerspace, in-depth course work or mentored independent projects can follow initial short experiences that spark an interest. We aim to provide a wide range of opportunities as we thoughtfully pursue ways to draw in students who might otherwise dismiss some of the more technical pursuits. Our goal is to infuse the curriculum and community with enough experiences that it will be difficult to graduate after four years without having participated in some makerspace run activity. Our small community can effectively publicize the opportunities the makerspace offers as well as direct students to the individuals with the right expertise. Fortunately, we are part of a five college consortium with open course enrollment, including the University of Massachusetts, Amherst, and Smith College that offer engineering programs. Students graduating from Mount Holyoke regularly continue on to graduate school or careers in engineering, though only a few complete our dual degree program.

Workshops require a few hour commitment, occur outside of class time, are voluntary, and free. For example, the Halloween costume making workshop is preceded by workshops on wearable electronics and Arduinos, and a prize is given for best costume in both the technical and non-technical categories. We hold Chocolate Lab before Valentine's Day, using the first workshop to introduce CAD and 3D printing to students, and the second to vacuum form the molds and teach the materials science of tempering chocolate. Bicycle tune-up

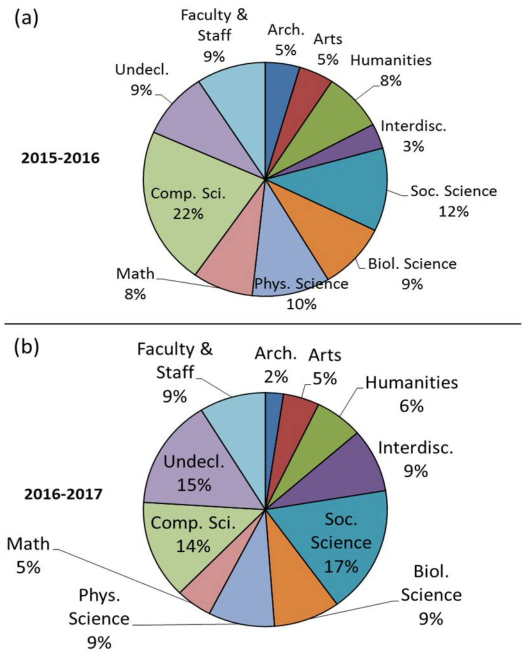

Figure 2 Self-reported majors of students registering for workshops (a) 2015-16 academic year (YR1) (b) 2016-17 academic year (YR2)

day in the spring encourages students to tune up and learn simple repairs for their bicycle.

Students must complete an online form to attend a workshop, and Fig. 2 shows the self-reported majors of participants who signed up for one of the twenty workshops offered in the first two years of operation. Double majors are counted twice, and individual students who sign up for multiple workshops are counted only once. "Interdisciplinary" includes international relations, which consists of humanities and social science classes, and environmental studies, which requires a mix of humanities, social science, and science courses. For a full list of how categories map to our majors, see Appendix A. In our first year, 124 individuals registered for workshops, and in our second year, 107 registered, though not all reported majors (80 did in YR1, and 117 in YR2). The number of majors represented increased about 40%, from 21 majors to 30 majors. Since students must declare their majors after three semesters, the increase in "undeclared" majors suggests we successfully reached more younger students in the second year (from 8 individuals to 19). We do see that computer science is the most common major, but represents 22% of the students in the first year, dropping to 14% in the second year. Table 1 reports the representation of majors across the college for comparison, as recorded by the registrar in February of 2016 and 2017 and averaged. Computer science represents only 4% of our students, and social sciences and the non-arts humanities are under-represented in the workshops.

In contrast to short, voluntary workshops, classes offered in the makerspace ask for a substantial time commitment. iDesign Studio is now open to all years, offered every semester, and suffers from a waitlist. Architecture classes regularly use the laser cutter and 3D printer. Faculty are encouraged to link their classes when possible, which fits best when two complementary classes have a substantial project as part of the course. A robotics course joined with a

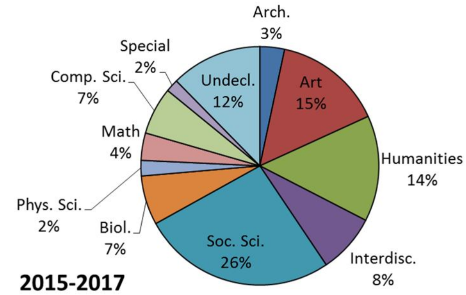

Figure 3 Majors of students enrolled in courses with a mandatory makerspace component

Table 1 Declared majors of all students, average from Feb 2016 and '17

Arch	Art	Hum.	Inter.	Soc.	Biol.	Phys.	Math	CS	Spec.	Undc.
1%	2%	17%	5%	18%	9%	3%	4%	4%	1%	35%

sculpture course for several weeks to create interactive sculptures, and iDesign Studio joined a costume making class to orchestrate a live performance with interactive lighting on costumes. Courses offered in one department (e.g. theater) that are linked to a significant collaborative makerspace experience help to draw in a wider range of students.

Courses with substantial makerspace engagement are still largely voluntary, though students might be motivated by distribution requirements or major requirements. We are extending the idea of academic makerspace engagement to include short exercises within existing classes. In this way, a student who might never consider entering the makerspace has a mandatory course experience, without requiring a large time commitment. For example, an international relations class on American Foreign Policy brought 25 students through a drone rover exercise. The students assembled rovers and programmed beacons during one class in the makerspace, and brought them to a large space to execute a "humanitarian mission" simulation in the following class. Students reflected on the moral, ethical, and political elements of drones, and their impact on warfare and aid. In another interdisciplinary class, over 100 students studying "The Future of Jobs" had the chance to build robots. A Gender in Science course brought students in to experience learning to first-hand through a lesson with Arduino microcontrollers. The experience helped the students think about introductory computer science, a topic under discussion in the class. Our introductory entrepreneurship class regularly brings students to the makerspace to learn what tools are available to design and prototype products.

Figure 3 shows the distribution of majors reached by our academic coursework, which includes 27 different courses over four semesters, some courses being offered every semester (see list in Appendix B). We see a larger percentage of non-STEM majors (80%), compared to our second year of workshops (63%), suggesting that both short and substantial engagement with the makerspace as a part of a course is an effective way to reach majors beyond the sciences, and the arts. The majors of the students in the courses were acquired from the registrar in the summer of 2017, and may not be the major declared while taking the course. Comparing these numbers to Table 1, we see that 80% of our students do have non-STEM majors, but art and architecture are overrepresented, along with social sciences. This is unsurprising given the particular classes that have embraced the makerspace thus far. Additionally, students may have been undeclared when they enrolled in the class, but not when the majors data were acquired.

The final way for students to engage with the space is through independent projects, which may be personal or academic. Introductions to the space and the tools free the imagination to conceive of personalized gifts, custom designed objects that fit perfectly in the dorm room, awards and swag for a student org, solutions to research problems, and more. Each semester, we solicit proposals from students who seek modest funding and academic credit for projects. While we track data from students receiving funding from the makerspace, our numbers are small, and we do not yet have a system in place to collect information for other individual projects.

CHALLENGES FACED BY THE MAKERSPACE AT MOUNT HOLYOKE

While the women's liberal arts setting offers many opportunities, we have faced a range of challenges in these first two years, some of which are related to the small size of our school and our student population.

Our current location limits the way we can use the space, though the upcoming expansion will address these issues. First, we cannot create dust in the space without affecting other activities like large format printing, which partly determines the tools and equipment we can offer. Second, we cannot concurrently run more than one event in the space. The new space is being designed to support simultaneous activities.

The workshops face the challenge of finding a time for our overcommitted students to attend, given their voluntary nature. With a larger student population, a very small fraction need to be available in order to run a successful 10 – 20 person workshop. We work to advertise effectively and have been experimenting with best times to offer workshops. The optimal time appears to be shortly after the cafeteria dinner time.

Attaching the makerspace experience to an academic class assures student participation. The challenge is to find faculty available to teach a hands-on course in the makerspace and to inform faculty across disciplines about the possibilities, assisting those unfamiliar with the technologies to generate ideas that fit into existing courses. Most of the science and studio art professors must teach courses for the major or service courses for other majors. For perspective, computer science had 4.5 tenured or tenure track faculty for the past two years. With so few faculty, it is difficult to offer elective classes tailored to non-majors.

To address the challenge of staffing new courses, Mount Holyoke hired an engineering professor who begins in the fall of 2017 and is tasked with offering at least three hands on courses a year. We hired a digital music professor, a lecturer in entrepreneurship, and are searching in design. Dedicated faculty committed to more project based courses are critical to spark the imagination of the faculty more broadly. Fortunately, our faculty is accustomed to the "art museum" model of student experience, in which they bring their class to the museum for one or a few lessons during the semester. These lessons may be taught by the art museum staff or by the professor. We are doing outreach to the faculty to help them understand that the makerspace is a similar resource through announcements at faculty meeting and advising training, a teaching retreat, and activities targeting faculty.

Staffing the space continues to be a significant challenge. Our full time coordinator struggles to support the current demand, even with assistance from paid student workers. We hired a few dedicated makerspace students, who joined the team of media lab workers and course TAs that are organized and supervised by Library, Information, and Technology Services. These students staffed the space in the evenings and supported specific course needs. Two problems arose. First, the assembled team is less coherent since they have different primary roles. The second problem stems from small numbers, and a lack of expert users at the college. Maintaining continuity of knowledge has been problematic with only two or three student staff trained to maintain equipment and run or assist with workshops. Few first-year students are prepared to step into the role of supporting workshops, and with the large number of students who study abroad in their junior year, it has been challenging to find reliable students. With few dedicated employees, there is little room for error, and illness or other unanticipated circumstances can disrupt workshops and facility availability. Our attempts to invite volunteers to assist during workshops in exchange for time or supplies in the makerspace has not yet generated interest.

In response, we trained all student staff to supervise the laser cutter in our second year, the most common bottleneck for student projects. We are implementing a common training for the student staff, to unify their knowledge and approach to helping students in the space, and are considering extended training for students with less technical experience. As we continue growing our user base and move into the larger space, we hope to hire enough experienced student staff to provide more continuity and flexibility.

DISCUSSION

The makerspace at Mount Holyoke strives to embody the liberal arts experience while remaining conscious of assumptions and barriers that students bring with them upon entering. In particular, not only do most lack a technical background, they are hesitant to acquire it. This lack of technical penchant poses a barrier across campus, particularly outside of the STEM disciplines. For example, in entrepreneurship classes, students initially brainstorm social solutions to global and local problems and must be pushed to consider technical solutions. This is in contrast to one author's previous experience teaching in a business school at a state university, with a class full of white men, who immediately brainstorm technical solutions.

In our two years of operation, we have increased both the total number of students who engaged in workshops or academic experiences, and increased the diversity of majors. While computer science and some arts are overrepresented, incorporating a makerspace experience into coursework helps reach more majors. We have graduated only one year of students who enrolled in iDesign their first year, with four of the fourteen becoming computer science majors. Survey data examining changes in self-efficacy are underway. We do not yet have data on whether the shorter experiences have a meaningful impact on students' perceptions of themselves or technology, and it is too soon to have longitudinal data on course and career choice. As we design our new space, we are working on data collection systems that will help us to assess whether we are accomplishing our goals of broader technical literacy and influencing course choices of students.

Attracting diverse students is critical. Retaining people who walk through the doors is equally important. While music, art, and entrepreneurship may bring people who do not consider themselves fluent with technology into the makerspace, we need a collaborative environment that makes it clear that everyone has something to offer. There are many students who think that art is unapproachable, that foreign languages and cultures are intimidatingly incomprehensible, or who would prefer to only tackle technical problems in isolation. Craftspeople and artists can elevate the level of making with expertise in textiles, fashion, and more. Psychologists and sociologists can design a more impactful user or audience experience. The historian might recreate older, yet still effective, ways of interacting with the material world. It is our hope that participants entering the space will observe the diversity of role-models already engaged and see themselves as welcomed. The diverse leadership strives to identify barriers to underrepresented groups, creating policies and training that lead to an inclusive space Makerspaces often emerge from either the arts or from engineering, and many of our initial users do come from studio art, architecture, and computer science. But the majority of users do not enter with extensive knowledge and experience, and do not look like the stereotypical people seen programming, woodworking, or machining.

Our student workers embody this diversity of backgrounds and experience, and have been key in building community in the space without making it exclusive or intimidating. Looking forward, we hope to build on Mount Holyoke's track record of near-peer mentoring [9]. Student workers need training not only on the technical knowledge, but on how to avoid alienating users and how to intervene when other users inadvertently discourage newcomers.

A makerspace can bring together students in a way that empowers them to overcome preconceptions of their interests and capabilities. While the makerspace may focus on tangible creation, it is becoming the hub of interdisciplinary collaboration and creativity on campus that will help students find the resources they need for any project. We continue to build our hands-on course offerings, and are reaching out to faculty, helping them to understand how the current and future makerspace can support their learning goals. Our goal is to infuse the four year Mount Holyoke experience with educational technology experiences, improving the technical literacy of our students and attracting students from underrepresented groups into engineering and computer science careers. We are also extending our reach beyond our walls, holding workshops for middle school and high school girls, and collaborating with organizations like Girls Inc. and Boys and Girls Club. HackHolyoke, the gender-balanced regional hackathon founded by one of the first iDesign Studio students, exemplifies our goal of Tech for All. Providing access to facilities for interested students is a first step. A thoughtful pedagogical approach to engaging new users allows us to spark interests and build confidence among diverse groups.

References

[1] Mount Holyoke College Institutional Research, "New Student Survey: A report on new students' interests in selected subject areas, 2010-present," 2015.

[2] D.H. Uttal and C. Cohen, "Spatial Thinking and STEM Education: When, Why and How?," *Psychology of Learning and Motivation,* pp. 147-181, 2012.

[3] S. Erin A. Maloney, E. A. Maloney, S. Wacchter, E. F. Risko and J. A. Fugelsang, "Reducing the sex difference in math anxiety: The role of spatial processing ability," *Learning and Individual Differences,* vol. 22, no. 3, pp. 380-384, 2012.

[4] C. J. Stephen and W. M. Williams, Why Aren't More Women in Science? Top Researchers Debate the Evidence, American Psychological Association, 2007.

[5] National Science Board, "Science & Engineering Indicators 2016," 2016.

[6] P. Nicholson and S. Mulvey, "American Institute of Physics focus on Physics Bachelor's Degrees," American Institute of Physics, November 2015.

[7] R. Wang. [Online]. Available: http://rayshobby.net/sqrwear/.

[8] P. F. Klemperer, S. Mensing, B. W.-L. Packard and A. St. John, "iDesign Studio: Gateway to Innovation and Entrepreneurship via Incubation Curriculum," *International Sympoisium on Academic Makerspaces,* 2017.

[9] "HackHolyoke," [Online]. Available: http://www.hackholyoke.com/.

[10] H. Pon-Barry, B. W.-L. Packard and A. St. John, "Expanding capacity and promoting inclusion in introductory computer science: a focus on near-peer mentor preparation and code review," *Computer Science Education,* vol. 27, no. 1, pp. 54-77, 2017.

APPENDIX A: COURSE MAPPING

Art (performing and visual)	Art Studio Dance Theater Music
Biological Sciences	Biochemistry Biology Neuroscience
Computer Science	Computer Science
Humanities	Film Studies Ancient Studies Art History Critical Social Thought East Asian Studies English French Gender Studies German Studies History Italian Middle Eastern Studies Medieval Studies Philosophy Religion Russian & Eurasian Studies Romance Languages South Asian Studies Spanish
Interdisciplinary	Environmental Studies International Relations
Math	Mathematics Statistics
Physical Sciences	Astronomy Chemistry Geology Physics
Social Sciences	Anthropology Economics Geography Politics Psychology Psychology and Education Sociology
Special Major	Special Major
Undeclared	Undeclared

APPENDIX B: MAKERSPACE COURSES

Term	**Section and Title**
Fall 2015	ARTST-226DH-01 Printmaking/Digital Hybrid ARTST-395SS-01 Senior Studio COMSC-109-01 iDesign Studio
Spring 2016	ARCH-225ED-01 Interm.: Environmental Design ARCH-305DT-01 Digital Design and Theory ARTST-137TC-01/THEAT-180-01 Intro to Technical Theatre ARTST-226BC-01/THEAT-220BC Costumes Beyond Clothing ARTST-226DH-01 Printmaking/Digital Hybrid ARTST-390-01 Advanced Studio ARTST-395SS-01 Senior Studio COLL-115GR-01 Global Challenges COMOR-349SE-01 Social Entrepreneurship COMSC-109-01 iDesign Studio IR-270-01 American Foreign Policy RELIG-201-01 Reading the Qur'an
Fall 2016	ARTST-246-01 Sculpture I ARTST-256-01 Printmaking I ARTST-257-01 Printmaking II ARTST-390-01 Advanced Studio ARTST-395SS-01 Senior Studio BIOL-145BN-01 Intro to Biological Inquiry COMSC-109-01 iDesign Studio EOS-210-01 Entrepreneurship: Opp./Impact EOS-310-01 Entrepreneurship: Social/Econ FYSEM-110FA-01 Fashion, Style and Design FYSEM-110GS-01 Gender in Science FYSEM-110PY-01 Anthropology of Play PSYCH-201-01 Statistics
Spring 2017	ARTST-226DH-01 Printmaking/Digital Hybrid ARTST-269-01 Japanese Papermaking ARTST-280CT-01 Color in Three Dimensions ARTST-390-01 Advanced Studio ARTST-395SS-01 Senior Studio COMSC-109-01 iDesign Studio EOS-229-01 Social Impact Enterpr./Innov. EOS-239-01 Organizations and Finance THEAT-224-01 Costume Design II