COUNCIL ON SCIENCE AND TECHNOLOGY

2015 – 2016 Annual Report

I. Introduction

The **C**ouncil on **S**cience and **T**echnology serves the University by catalyzing and supporting intellectual exchange, interdisciplinary research, excellent courses, and multidisciplinary collaboration that broaden participation in and appreciation of science, technology, engineering and mathematics (STEM). By seeking to **broaden** and **deepen** participation in STEM, the CST aims to provide unique experiences for undergraduate and graduate students, as well as to support faculty in their research and course development.

The Council is guided by the following overarching goals to

- Collaborate with university colleagues to educate a STEM-literate society.
- Engage in and support interdisciplinary research.
- Support synergies that invite a broad and diverse community to engage with STEM and to explore intersections of STEM with the arts, humanities, and social sciences.

Throughout the 2015-2016 academic year, the CST partnered with colleagues in engineering, the natural sciences, the arts, the humanities, and the social sciences to brings together diverse perspectives that explore the intersections and shared creativity across disciplines. Members of the CST Administration and Executive Committee are listed in Appendix A. The Council awarded 14 grants to faculty from African American Studies, Architecture, Astrophysics, the Center for Information Technology Policy, School of Engineering and Applied Sciences, Comparative Literature, Ecology and Evolutionary Biology, Geosciences, History, Lewis Center for the Arts, Molecular Biology, and Physics. Six of the grants were made in co-sponsorship with the 250th Fund award and two were made in collaboration with the Humanities Council.

The following sections provide an overview of the Council's key projects, including the Science and Engineering Education Initiative, educational research, and synergistic activities. More detailed information about the CST and our activities is available on our website: http://cst.princeton.edu.

II. Science and Engineering Education Initiative

In 2010, the Council proposed the Science and Engineering Education Initiative, which was then passed by faculty vote. The Initiative aims to inspire and prepare all undergraduates, irrespective of their majors, to become scientifically and technologically literate citizens and decision-makers. The primary recommendation of the Initiative was to change the undergraduate general education requirement for the Science and Technology (ST) designate. As a result, undergraduates are required to complete at least two ST-designated courses: at least one with a lab (STL) and a second that may be taken without a lab (STN).

To provide a rich variety of ST offerings, the Council supports faculty in revising and developing science and engineering courses that emphasize the role of science and engineering in society. The Council offers financial resources to faculty developing new and enhancing existing ST-designated courses. In addition to financial resources and guiding course goals, members of the CST administration were

available to assist faculty with the enhancement of existing ST-designated courses and the development of new ST-designated courses. During the 2015-2016 academic year, Princeton University offered 35 ST-designated courses that did not carry a substantial prerequisite and aligned with the spirit and intent of the Science and Engineering Education Initiative. A full list of these courses and examples of our collaborations with faculty is available in Appendix B.

III. Educational Research

The Council has launched an educational research agenda focused on understanding the STEM educational experience of undergraduates, as well as the faculty perspective on STEM education at Princeton University. Research findings will assess the impact of the Council, inform future work, and contribute to the growing body of literature on excellent and equitable STEM education. During the 2014-2015 academic year, we continued two research projects. Data collection and analysis will continue for several academic years. The following subsections describe the two current projects.

a. Freshmen Scholars Institute

The Princeton University Freshmen Scholars Institute (FSI) aims to engage a highly motivated community of incoming freshmen in rigorous coursework and meaningful social and professional development. As evidenced by the existing research literature, summer bridge programs like the FSI increase retention and graduation rates, as well as improve students' self-efficacy and social capital. Many of the existing studies of summer bridge programs primarily use quantitative data to draw conclusions. The voices of the participants, who are often first-generation, low-income students, are missing from the literature.

To begin to fill these gaps in the literature, CST is conducting a research study on the FSI. The guiding research question is: *As described by the students, what is the lived experience and longitudinal impact of the FSI?* In particular, we are interested in describing the FSI through the students' voices, with a focus on the new science and engineering (STL) courses for STEM majors. We are also interested in gaining the students' perspective on the longitudinal impact of the FSI on their persistence in a STEM major, on their overall scientific literacy, and on their overall satisfaction with the undergraduate experience at Princeton University. Preliminary findings suggest:

- The salient features of the FSI experience that contributed to student's academic success included:
    - Providing opportunities for students to engage in authentic scientific and engineering endeavors early in their undergraduate careers through the engineering and molecular biology summer courses
    - Supporting faculty members' use of evidenced-based teaching practices that made the content accessible in the MOL and EGR courses
    - Cultivating an environment conducive to multifaceted interactions between the faculty and students, as well as between the course fellows and students
- The FSI community that formed during the summer bridge program contributed to student success by:
    - Increasing the students' perceived social fit and coping skills
    - Decreasing students' anxiety about social pressures

- Enhancing students' social capital, a network of peers and mentors who facilitate access and participation in a community
- Cultivating a cohort of scholars who relied on each other for academic and social support during the summer program and academic year
- Supporting faculty in their desire to link with FSI students in a teaching and mentoring capacity

The CST is continuing to collect and analyze data. Findings have been shared with the FSI management team and will be available on our website.

b. CEE 262 Structures and the Urban Environment

The CST has supported CEE 262 for several years and recently received an award from the National Science Foundation (PI M. Garlock; see Synergistic Activities section below) to evaluate the course. Students in this course are exposed to fundamental ideas in civil and structural engineering through the great works of pioneering engineers. A central message of this course is that engineering is a creative discipline that allows for creative and aesthetic explorations within constraints. CEE 262 is open to all majors and is offered every spring semester. The course enrolls approximately 150 students each spring semester. The Council developed and implemented a mixed-methods study to evaluate the impact of the course on students' cognition and affect. Evaluation of the course is ongoing, but preliminary findings from the study revealed: 89% of students experienced moderate to great gain in interest in engineering; 85% reported moderate to great gain in recognizing engineering as a creative profession; 83% indicated moderate to great gain in understanding how engineering helps people address real world issues; and, on average, 78% of students reported a moderate to great gain in their STEM abilities. The CST will co-author articles for conference presentations and journal publications to disseminate findings.

IV. Synergistic Activities

The Council supports synergistic activities that attend to the fundamentals of STEM, explore the societal impact of STEM, and investigate the connections across the natural sciences, engineering, arts, humanities, and social sciences. Activities include courses, workshops, seminars, projects, informal learning opportunities, and events for faculty, post-doctoral fellows, graduate and undergraduate students, and community members. The following subsections describe the Council's 2015-2016 synergistic activities.

a. StudioLab

The CST welcomes and encourages students and faculty from all the University divisions to engage across the disciplines in ways that broaden their intellectual experiences and perspectives, inspire new synergies, and cultivate creativity. We recently developed the StudioLab to bring together students, faculty and staff, independent of area of concentration, to explore the intersections and shared creativity across STEM, the arts, humanities, and social sciences. The 2500 sq. ft. space is highly customizable, allowing students and faculty to use and adapt the space to fit their needs. Programmatic initiatives within the StudioLab will include courses, labs, studios, research, projects, workshops, events,

and informal interactions. These initiatives will advance engagement and diversify participation within and across the disciplines.

b. Transformations in Engineering and the Arts

STC/EGR/MUS 209: *Transformations in Engineering and the Arts* explored the parallels and intersections of design/composition in engineering and the arts, emphasizing a merging of artistry and systematic thinking. Students will use what they learned to create as engineer-artists and artist-engineers. Offered during the Spring 2016 semester, and held in the StudioLab, the course was organized around four modules: A) Visuals, B) Sound, C) Structure and 4) Movement, led by faculty from COS, MUS, CEE, MAE with the participation of faculty from the Lewis Center for the Arts. The modules were unified through "transformations" that engage the disciplines of engineering and the arts and allow the course to serve as an introductory experience for students of varying academic backgrounds. The CST will continue to offer and explore ways to scale-up the course.

c. The Creative Art of Structural and Civil Engineering (CASCE)

The CASCE project is funded by the National Science Foundation (NSF DUE 14-32426, 14-31717, and 14-31609; PI M. Garlock, Co-PI E. Laffey; $498,814.00). Recent reports from the Office of the President of the United States and the National Academy of Engineering urge the nation to increase student retention in science, technology, engineering and mathematics, and to educate a STEM-literate populace. Uninspiring introductory courses, poor teaching, and lack of effective dissemination of best practices are major obstacles that stand in the way of achieving these goals. Faculty members from Princeton University, Virginia Tech and the University of Massachusetts Amherst are partnering on a project entitled "Advancing the Dissemination of the Creative Art of Structural/Civil Engineering" (CASCE) with the aim of overcoming these obstacles through supporting the dissemination and implementation of an introductory civil engineering course that is to be enhanced with research-based pedagogy. The main objectives of the project are to: (1) transform an introductory engineering course to dramatically improve interactivity and accessibility for non-STEM students; (2) ensure that the course takes a form that can be readily adopted into the engineering and general education curricula of many types of institutions of higher education (e.g., undergraduate institutions, research universities, etc.); and (3) facilitate dissemination, adoption, and continuous improvement of the courses beyond the audience already being reached. Members of the Council on Science and Technology serve as Co-PI (Evelyn Laffey) and part of the management team (Aatish Bhatia and Laura Sarubbi). Their main responsibilities include leading project evaluation and supporting the infusion of evidenced-based teaching practices into the targeted courses.

d. STL Courses for the Freshmen Scholars Institute

The Princeton University Freshmen Scholars Institute (FSI) aims to engage a highly motivated community of incoming freshmen in rigorous coursework and meaningful social and professional development. As evidenced by the existing research literature, summer bridge programs like the FSI increase retention and graduation rates, as well as improve students' self-efficacy and social capital. Some of the salient

features of summer bridge and first-year engineering experiences that contribute to student success include: using evidenced-based teaching practices, providing opportunities for students to engage in authentic scientific and engineering endeavors early-and-often, and cultivating opportunities to enhance faculty-student interaction. The Council partnered with the FSI management team and faculty in Molecular Biology and Electrical Engineering to assist with the development and evaluation of two new courses: MOL 152 Laboratory Research in the Life Sciences and EGR/STC150 Foundations of Engineering. The development of the courses was informed by existing literature on STEM education and findings from a study conducted by the Council in 2014.

e. Summer Institute

The CST supported Prof. Rebecca Burdine (Molecular Biology and Member of CST Executive Committee) in hosting the 2015 Northeast Summer Institute (SI; http://www.academiessummerinstitute.org). The Northeast SI welcomed over 45 faculty from diverse academic institutions to Princeton University in June 2015. The Institutes emerged from the 2003 National Research Council report, Bio2010: Transforming Undergraduate Education for Future Research Biologists. The report concludes that faculty development is a crucial component of improving undergraduate education. The Summer Institutes provide venues for college and university faculty and instructional staff to meet for intensive discussions, demonstrations, and working sessions on research-based approaches to undergraduate education. During the 2015-2016 academic year, Prof. Burdine and the CST welcomed the 2015 summer participants back to campus for a two-day SI follow-up meeting.

f. Women in STEM Panel and Academic Expo

The CST welcomed the Class of 2019 by hosting the annual Women in STEM Panel and participating in the Academic Expo during Freshmen Orientation. The Women in STEM Panel was moderated by the Council Associate Director, Evelyn Laffey. Panel participants included: Nozomi Ando (Chemistry), Maria Garlock (Civil and Environmental Engineering), Jessica Irving (Geosciences), Janine Nunes (Mechanical and Aerospace Engineering), Heather Thieringer (Molecular Biology) and Nicole Gonzalez (ELE ’16, student representative). During the Academic Expo, members of the Council staff greeted approximately 200 students, shared information, and answered questions.

g. Evnin Lectures

The Evnin Lectures were established with a gift from Anthony B. Evnin to promote a better understanding of the critical roles of science and technology in all aspects of human endeavor. Since 1991, the Council on Science and Technology has invited luminaries in the fields of science, math, engineering and technology to explore topics of interest to a broad audience. These lectures are free and open to the public. The Council hosted the following Evnin Lecture:

- On April 20, 2016, **Francisco Valero-Cuevas**, Professor and Director of the Brain-Body Dynamics Laboratory at the University of Southern California, Los Angeles, presented *Dexterity.* His talk explored the intersection of human movement, mathematics, biology, and sports. Dexterous manipulation depends on our ability to use the fingertips to dynamically stabilize objects—as

when squeezing a lemon or buttoning a shirt. By extension, we can speak of "leg dexterity" as the ability to dynamically stabilize the interaction of the foot with the ground—as when performing cutting maneuvers or landing from a jump. Quantifying finger and leg dexterity is critical to evidence-based medicine, rehabilitation and athletic training. Dr. Valero-Cuevas presented several clinical and athletic studies indicating the utility of the approach developed by him and his team to understanding the integrity of the neuromuscular system in health and disease. He also proposed future avenues to understand and promote dexterity in clinical populations and elite athletes.

h. Co-Curricular and Informal Learning Experiences

The CST offered the following co-curricular, extra-curricular or informal learning opportunities:

- In Summer 2015, two undergraduate students spearheaded the "Mapping Princeton" project, a continuation of their work in their Fall 2014 Freshman Seminar, "The Science and Art of Mapping the World." The students worked closely with CST Associate Director Catherine Riihimaki to create an atlas of conventional and innovative maps of the University and its community. Hard copies were distributed to various campus stakeholders and digital copies are available here: http://cst.princeton.edu/sites/cst/files/mapping_princeton_0.pdf. The project also formed the core of the Spring 2016 Sustainability Kiosk in Frist Campus Center.
- In 2015-2016, CST strengthened collaborations with the Princeton Art Museum that began with CST Associate Director Catherine Riihimaki bringing students from ENV201B to the Museum to use the art collection to discuss how climate scientists reconstruct past environments. In December 2015, Dr. Riihimaki and Dr. Veronica White, Curator of Academic Programs, convened a panel of three natural science faculty and one art historian to discuss the collective interpretations of one of the prominent paintings in the American Art gallery. The event was attended by ~200 members of the community and received much positive feedback. In May 2016, Dr. Riihimaki facilitated faculty discussions about two still-life paintings during a closed-door event "The Art of Food" at the Museum organized by Dr. Julie Dweck, Andrew W. Mellon Curator of Academic Engagement.
- The CST is dedicated to creating extra-curricular opportunities in which undergraduate and graduate students may take on leadership roles. This past year we created the CST Ambassador Program. Students were invited to apply and become involved in three initiatives: (1) Event Planning, including organizing workshops, lectures, and book clubs, (2) StudioLab Programming, (3) Outreach within Princeton University and surrounding communities. A total of 13 undergraduate and 13 graduate students became involved in furthering the mission of the CST. Activities ranged from leading a discussion of, "The Immortal Life of Henrietta Lacks" to creating a summer outreach program for rising high school seniors in the area.
- During the 2015-2016 academic year, the CST partnered with the Writing Center to create the STEM and Writing Ambassadors program. Eight undergraduates worked with staff members from the CST and the Writing Center to plan and implement two workshops designed to help students with writing in their STEM courses.

- In the fall of 2015, the CST partnered with the Butler and Wilson residential colleges, as well as a Resident Graduate Student in Wilson College, to pilot a dinner discussion between students and faculty. This informal discussion was held in the Wilson Private Dining Room, and was attended by a number of students, Dr. Michael Strauss (AST) and Dr. Alexander Ploss (MOL). The topic of this pilot dinner was "Technology in Research", and faculty discussed the aspects of their research that have been made possible by recent technological advances, as well as a broader range of topics, with the undergraduates who attended. The CST hopes to continue this series in the upcoming academic year.
- In Summer 2016, CST Associate Director Aatish Bhatia mentored 3 undergraduate students (Kathleen Ma, Jonathan Zong, Sarah Wang) on a science communication project, in collaboration with science radio host Robert Krulwich (*Radiolab/NPR*). The goal is to reimagine the act of communicating ideas on the web to include richer interactive experiences. The project participants are currently developing a web story about plants, that merges art and science, and have gained skills in science communication and storytelling, web programming and animation, graphic design and digital art. As part of this wider project, Aatish developed the following 'interactive explainer' on the concept of entropy: https://aatishb.github.io/entropy/
- CST Associate Director Aatish Bhatia participated on panels on *The Art of Science Communication* (organized by Princeton Innovation Journal), *Beyond the Podium: Educators on Social Media* (organized by Career Services and the Office of Communications), was a *STEM Career Panelist* as part of the American Museum of Natural History's NYC Science Research Mentoring Consortium, conducted science communication training sessions for undergraduate tutors at the McGraw Center, and was a "grown up guest" on Princeton University's student run late-night talk show, *All-Nighter with Anna Aaronson*. He also consults on STEM topics for the *WHYY* radio show *The Pulse*.
- CST awarded over $5000 to undergraduate and graduate students via the Student Activities Funding Engine (SAFE). The majority was award to undergraduate students in support of their independent research. Additionally, undergraduate student groups, such as EClub, Neuroscience Network, and Film Production, were supported for their activities and endeavors. Graduate students were offered honoraria for research and outreach to the Princeton community.

i. Conferences, Presentations, Publications & Committees

A number of the CST administration and faculty attended relevant national and regional conferences. These conferences offered excellent professional development and learning opportunities, as well as venues to share the work of the CST. A few examples of conference attendance and presentations are as follows:

- Catherine Riihimaki and Evelyn Laffey published: Visnjic, K., Riihimaki, C. A., Sealfon, C., and Laffey, E. (2015), ISLE-inspired Design Laboratory Transformation at Princeton University: Year Two Results, *2015 Physics Education Research Conference Proceedings*, 347-350, doi:10.1119/perc.2015.pr.082.

- Catherine Riihimaki published: Sewall, J. O., Riihimaki, C. A., and Kadegis, J. (2015), Orbital control, climate seasonality, and landscape evolution in the Quaternary Rocky Mountains, *Geomorphology*, 250, 89-94, doi:10.1016/j.geomorph.2015.08.020.
- Catherine Riihimaki published: Schachtman, N., MacGregor, K. R., Myrbo, A., Hencir, N. R., Riihimaki, C. A., Thole, J., Bradtmiller, L. I. (2015), Lake core record of Grinnell Glacier dynamics during the Late Pleistocene and Younger Dryas, Glacier National Park, Montana, U.S.A., *Quaternary Research*, doi:10.1016/j.yqres.2015.05.004.
- Catherine Riihimaki presented: Riihimaki, C. A. (2015), Long-term partnerships work best: lessons from transforming classrooms through the Princeton Science and Engineering Education Initiative, *Geological Society of America, Fall National Meeting, Abstracts with Program.*
- Catherine Riihimaki presented: Riihimaki, C. A. (2015), Engaging the whole campus: efforts to create a STEM-literate undergraduate population at Princeton, *Earth Educators Rendezvous*.
- In July 2015, Jaclyn Schwalm attended the Society for the Advancement of Biology Education Research (SABER) meeting in Minneapolis, MN. Editorship.
- In July 2015, Jaclyn Schwalm attended the Summer Institute on Course-Based Undergraduate Research Experiences workshop in Austin, TX.
- Aatish Bhatia collaborated with Sigrid Adriaenssens on developing a web-based fabric simulation tool to inspire creative exploration among artists and engineers. The tool is freely available at http://aatishb.github.io/drape/ and is described in a paper entitled '*Describing The Esthetics Of A Membrane Structure'* by Sigrid Adriaenssens, Aatish Bhatia, Ruy Marcello Pauletti (submitted for publication).
- Aatish Bhatia presented: Aatish Bhatia, Evelyn Laffey, Maria Garlock "Engaging Students with the Creative Art of Civil Engineering", Proceedings of the 2015 ASEE Annual Conference, New Orleans, LA.
- Evelyn Laffey presented: Evelyn Laffey, Aatish Bhatia, Maria Garlock, "Enhancing Student Cognition and Affect through the Creative Art of Structural and Civil Engineering", Proceedings of the 2015 ASEE Annual Conference, New Orleans, LA.
- In April 2016, Evelyn Laffey attended the AAU STEM Education Initiative Workshop in Laguna Beach, CA.

The Council participated in university-wide and strategic planning committees. The committees included: Committee on Classrooms and the Schedule, Committee on the Course of Study, Academic and Administrative Management Group, and the School of Engineering and Applied Sciences Taskforce on the Undergraduate Curriculum. Committees outside of the University include the New Jersey Higher Education Partnership for Sustainability and the AAU STEM Education Initiative Network.

V. Summary and Looking Ahead…

CST continues to serve the University by catalyzing and supporting intellectual exchange, interdisciplinary research, excellent courses, and multidisciplinary collaboration that broaden participation in and appreciation of science, technology, engineering and mathematics (STEM). As originally mandated, CST engages a broad audience in meaningful STEM experiences. Currently, CST aims to understand the dynamic nature of STEM in the 21st Century and provide diverse opportunities to engage members of the Princeton University community.

As we look to the future of the CST, we will continue to advance undergraduate STEM education through the *Science and Engineering Education Initiative*. Additionally, we will define and launch the *Living at the Intersections* initiative to enhance our current co- and extra-curricular programming, as well as support faculty research. The primary focus of the SEEI and Living at the Intersections will be to explore and promote the shared creativity across STEM, the arts, the humanities and social sciences. CST initiatives will continue to inform practice: new courses will emerge from supported research; multidisciplinary discussions will inform new research agendas and courses; rigorous evaluation on cognition and affect will inform educational practice.

Appendix A – Meet the CST

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Administration

Prof. Naomi E. Leonard; Director, Council on Science and Technology; Edwin S. Wilsey Professor of Mechanical and Aerospace Engineering

Dr. Leonard is the Edwin S. Wilsey Professor of Mechanical & Aerospace Engineering. She serves as the Faculty Director of the Council, overseeing the overall direction of the Council and future initiatives. In additional to her responsibilities at the Council, she is Associated Faculty with the Program in Applied & Computational Mathematics and Affiliated Faculty with the Princeton Neuroscience Institute and Quantitative and Computational Biology.

Dr. Evelyn H. Laffey; Senior Associate Director

Dr. Laffey serves as the administrative head of the Council. She is responsible for the daily operations, as well as long term and strategic planning in partnership with the Director. To advance the CST initiatives, Evelyn cultivates relationships with academic and administrative units to develop synergistic collaborations across campus. She remains active in educational research activities as she continues to study the intersection of cognition, affect, and identity within STEM education.

Dr. Aatish Bhatia, Associate Director, Engineering Education

Dr. Bhatia supports science and engineering education initiatives at the Council. He has disciplinary expertise in the fields of physics, bioinformatics, physics and engineering education, and science communication. His Ph.D. research focused on numerical methods to detect signatures of natural selection using genetic data. Aatish is actively engaged in science communication, and writes Empirical Zeal, an award-winning science blog. His popular science writing has been published online by WIRED and Nautilus Magazine, in print in The Best Online Science Writing 2012 (Scientific American Books).

Dr. Catherine Riihimaki, Associate Director, Science Education

Dr. Riihimaki supports science education initiatives at the Council. Her disciplinary expertise rests in the fields of environmental science, geoscience, and geographic information systems. Catherine has worked primarily in the US Rocky Mountains, with ongoing projects on Holocene environmental records from lake sediment in Glacier National Park, Montana, and coal-based evidence of river erosion in the Powder River basin, Wyoming and Montana. She continues to collaborate with colleagues across disciplinary boundaries by serving as the project expert in GIS.

Mrs. Laura Sarubbi, Program Coordinator

Mrs. Sarubbi is responsible for coordinating the daily operations of the Council. In addition to budgetary and program management, she coordinates student efforts and the creation of the Council's new StudioLab. Laura is responsible for developing, enhancing, and sustaining the new CST Student Ambassador program, which provides an opportunity for undergraduate and graduate students to engage with the CST activities.

Dr. Jaclyn Schwalm, Associate Director, Science Education

Dr. Schwalm consults with and is a lecturer in the Molecular Biology Department. She also serves as an Academic Advisor in Butler College. As part of the Science & Engineering Education Initiative (SEEI), Jaclyn worked with the faculty teaching Molecular Biology courses to incorporate research-based teaching practices, including greater levels of in-class interaction, the use of student-response systems, and increased formative assessment. More recently, her research has been focused on education. One of her current research projects focuses on better understanding the experiences of students who take part in the FSI, and how the FSI impacts these students' first few years at Princeton.

CST Executive Committee

The CST Executive Committee consists of several faculty members from diverse academic disciplines. The Committee members engage with the CST to advance STEM literacy, cultivate programming and courses that align with the mission, oversee the ST-designation, and allocate funding via the CST annual call for proposals. During the 2015-2016 academic year, the Executive Committee members were:

Rebecca Burdine, *Associate Professor of Molecular Biology*

Paul DiMaggio, *A. Barton Hepburn Professor of Sociology and Public Affairs*

Maria Garlock, *Associate Professor of Civil and Environmental Engineering; Director, Program in Architecture and Engineering*

Adele Goldberg, *Professor of Psychology*

Naomi Leonard, *Director, Council on Science and Technology; Edwin S. Wilsey Professor of Mechanical and Aerospace Engineering*

Daniel Marlow, *Evans Crawford 1911 Professor of Physics*

Howard Stone, *Donald R. Dixon '69 and Elizabeth W. Dixon Professor of Mechanical and Aerospace Engineering; Chair, Department of Mechanical and Aerospace Engineering*

Emily Thompson, *Professor of History*

Daniel Trueman, *Professor of Music*

Manjul Bhargava, *The Brandon Fradd, Class of 1983, Professor of Mathematics*

Appendix B – ST-Designated Courses that Aligned with the Science and Engineering Education Initiative with Examples of our Work with Faculty

Summer 2015

STL Courses – Science and Technology with Lab

*EGR/STC 150	Foundations of Engineering
*MOL 152	Laboratory Research in the Life Sciences

Fall 2015

STL Courses – Science and Technology with Lab

ANT 215	Human Adaptation
CEE 102B	Engineering in the Modern World
EEB 211	The Biology of Organisms
EEB 417B	Ecosystems and Global Change
*ENV 201B	Fundamentals of Environmental Studies: Population, Land Use, Biodiversity, and Energy
FRS 133	Materials World
FRS 135	State of the Earth: Shifts and Cycles
*GEO 102B	Climate: Past, Present, and Future
GEO 201	Measuring Climate Change: Methods in Data Analysis and Scientific Writing
*PHY 101	Introductory Physics I
PHY 115B	Future Physics

STN Courses – Science and Technology without Lab

AST 205	Planets in the Universe
*ENV 201A	Fundamentals of Environmental Studies: Population, Land Use, Biodiversity, and Energy
FRS 127	The Smart Band-Aid
FRS 129	Emerging Micro and Nano-Engineered Technologies
*GEO 102A	Climate: Past, Present, and Future
MAE 228	Energy Solutions for the Next Century
NEU 201	Fundamentals of Neuroscience
PHY 115A	Future Physics
WWS 353	Science and Global Security: From Nuclear Weapons to Cyberwarfare

Spring 2016

STL Courses – Science and Technology with Lab

*CEE 262B	Structures and the Urban Environment
ELE 201	Information and Signals
FRS 106	Art and Science of Motorcycle Design
GEO 103	Natural Disasters
GEO 202	Ocean, Atmosphere, and Climate
MOL 101B	From DNA to Human Complexity
PSY 101	Introduction to Psychology

STN Courses – Science and Technology without Lab

AST 204	Topics in Modern Astronomy
EEB 311A	Animal Behavior
ENE 202	Designing Sustainable Systems: Demonstrating the potential of sustainable design thinking
FRS 110	Personal Genomes, Medicine and Algorithms
FRS 124	The Everglades Today and Tomorrow: Global Change and the Impact of Human Activities on the Biosphere
FRS 138	Science, Society & Dinner
FRS 144	How the Tabby Cat Got Her Stripes
FRS 152	Drug Discovery: From Snake Venoms to Medicines
MOL 101A	From DNA to Human Complexity
*STC/EGR/MUS 209	Transformations in Engineering and the Arts
*WWS 350	The Environment: Science and Policy

*Description of the CST collaboration with faculty teaching the course provided below.

EGR/STC150: In this course, CST Associate Director Aatish Bhatia collaborated with the *Freshman Scholars Institute* (FSI) program and course instructors Dr. Claire Gmachl and Dr. Andrew Houck to help incorporate active learning exercises such as clicker questions, classroom demonstrations, and problem solving sessions. Aatish worked on mentoring students in problem solving sessions, and helped mentor the student peer assistants. Aatish participated in an education research project to understand the lived experience of students in this program as well as the impact of the program on their educational outcomes, and conducted student interviews and surveys to better understand students' FSI experiences and outcomes.

MOL/STC152: CST Associate Director Jaclyn Schwalm collaborated with faculty in the Molecular Biology Department and the *Freshman Scholars Institute* (FSI) program to design and teach a laboratory course that engaged undergraduate students in original scientific research. The course introduces students to hands-on, discovery-based research in the life sciences at the very beginning of the Freshman Scholar's college education. Students, by experiencing the excitement of working on their own research project and prototypes, will develop a more realistic and more inspirational impression of what it will mean to be a STEM major. Furthermore, they will enhance their biology content knowledge and laboratory skills.

ENV201A and ENV201B: In this course, CST Associate Director Catherine Riihimaki has co-taught the course as lead lab instructor since Fall 2013. In addition to redesigning the lab activities for the students to experience real-world research questions and methods, Dr. Riihimaki has worked with the two lecturers, Dr. David Wilcove (EEB and WWS) and Dr. Kelly Caylor (CEE) to create more opportunities for active learning within the lecture. Dr. Riihimaki has also served as the primary mentor for the AI team to ensure that the precepts are of consistently high quality. These efforts saw the course enrollment rise each year and the course evaluations increase, particularly in the lab and precept scores.

GEO102B and GEO201A: In this course, CST Associate Director Catherine Riihimaki worked with instructor Dr. Danny Sigman (GEO) and lead lab instructor and course coordinator Danielle Schmitt (GEO) to completely redesign the course in Fall 2015. It previously had been co-taught as a smaller seminar of ~30 students. In Fall 2015, the course had ~120 students. The CST supported the design of active learning activities during lecture, new lab activities to highlight climate research questions and methods, formative assessment opportunities throughout the semester, and exams as capstone experiences for the students. The course received strong student evaluations and will likely have over 200 students in Fall 2016.

PHY 101: In this course, CST Associate Director Aatish Bhatia worked with the course instructor Dr. Katerina Visnjic on revamping the syllabus, course assignments, and precept workshop activities. The course was modified to adopt evidence-based physics teaching practices such as the *Investigative Science Learning Environment* (ISLE) framework, as well as active learning exercises such as clicker questions and interactive lecture demonstrations. In addition, Aatish worked on incorporating *Direct Measurement Videos* into the homework assignments, giving students an opportunity to measure and analyze real-world data in their problem sets. To assess the impact of these course modifications, the instructors adopted the *Force Concept Inventory* (FCI), which demonstrated larger gains in student understanding compared to gains typically seen in traditional physics courses.

CEE 262: In this course, CST Associate Director Aatish Bhatia consulted with the teaching staff to improve educational outcomes, and helped design, implement, document, and assess interactive lecture demonstrations and activities. Aatish is part of a NSF funded project on furthering the *Creative Art of Structural & Civil Engineering* (CASCE), in collaboration with course instructor Dr. Maria Garlock and CST Senior Associate Director Dr. Evelyn Laffey, and has contributed to research in this area presented at the annual ASEE conference, helped organize an annual conference (held in 2016 at UMass Amherst), and helped disseminate course materials as well as our pedagogical approach to teaching civil engineering.

STC 209: In this course, CST Associate Director Aatish Bhatia worked closely with the course instructors Dr. Sigrid Adriaenssens, Dr. Maria Garlock, Dr. Naomi Leonard, Dr. Adam Finkelstein, and Dr. Jeff Snyder in planning the course, and on developing and implementing teaching material. Aatish developed programming demonstrations and assignments in the p5.js language that demonstrate graphic statics, 2D and 3D particle-spring models, hanging fabric simulations, control & feedback simulations (such as steering & flocking behavior), sound visualizations, and other interactive applications. Aatish also developed software to help students easily interface their p5.js programs with systems in the CST *StudioLab* such as the *Vicon* Motion Capture system, the *Kinect* motion sensor, the theatrical lighting system, and the *Leap* Motion Sensor. Aatish worked closely with students and faculty to ensure the continued success of this course, helped facilitate discussions and activities, and worked with students in office hours and on assignments and project work. Aatish's work on this course has resulted in research projects and collaborations with Dr. Adriaenssens and Dr. Jeff Snyder on real-time web based physics simulations of fabrics such as hanging cloth, accessible at https://aatishb.github.io/drape/

WWS350: In this course, CST Associate Director Catherine Riihimaki worked with co-instructors Dr. David Wilcove (EEB and WWS) and Dr. Jin Sato (visiting professor in EAS) to re-envision a course that previous had been taught by two scientists, to instead incorporate social science concepts consistent with Dr. Sato's background. Dr. Riihimaki participated in course development before the semester and met with the teaching team throughout the semester. She also oversaw mentoring of the AI team to ensure consistency and quality across the nine precept sections. The precepts were particularly valued by students in their end-of-semester evaluations.