

Council on Science and Technology

2013 – 2014 Annual Report

I. Introduction

With a continued focus on increasing scientific literacy, the Council on Science and Technology fosters research, education, and intellectual exchange that deepen and broaden understanding, experience, and appreciation of science, technology, engineering, and mathematics (STEM). The Council partners with colleagues in engineering, mathematics, natural sciences, the arts, humanities, and social sciences to explore and promote the relation of STEM with culture and the course of public affairs.

The Council is guided by the following overarching goals to:

- Collaborate with university colleagues to **educate** a STEM-literate society through formal and informal learning experiences.
- Engage in and support **research** that explores STEM education and interdisciplinary collaborations.
- Cultivate **synergies** among a broad and diverse community that bridge STEM, the arts, humanities and social sciences.
- Serve as a **clearinghouse** on innovations that promote excellent, equitable, and innovative STEM research and education.

Throughout the 2013-2014 academic year, the Council collaborated with faculty and students on several courses and initiatives. The following sections provide an overview of the Council's key projects, including the Science and Engineering Education Initiative, educational research, the Evnin Lecture series, and meaningful informal and co-curricular learning experiences.

II. Science and Engineering Education Initiative: ST Course Enhancement and Development

In 2010, the Council proposed the Science and Engineering Education Initiative that was 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 the 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. During the 2012-2013 academic year, the Council produced a list of ST Course Goals and developed an ST-designation application process for faculty. This year, the Council enhanced the ST Course Goals to include recommendations from the 21st Century Learning Goals¹ and ABET Learning Outcomes². See Appendix A for the revised ST Course Goals. During the 2013-2014 academic year, Princeton University offered 23 STN courses and 17 STL 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 is available in Appendix B.

¹ Partnership for 21st Century Skills: <http://www.p21.org/>

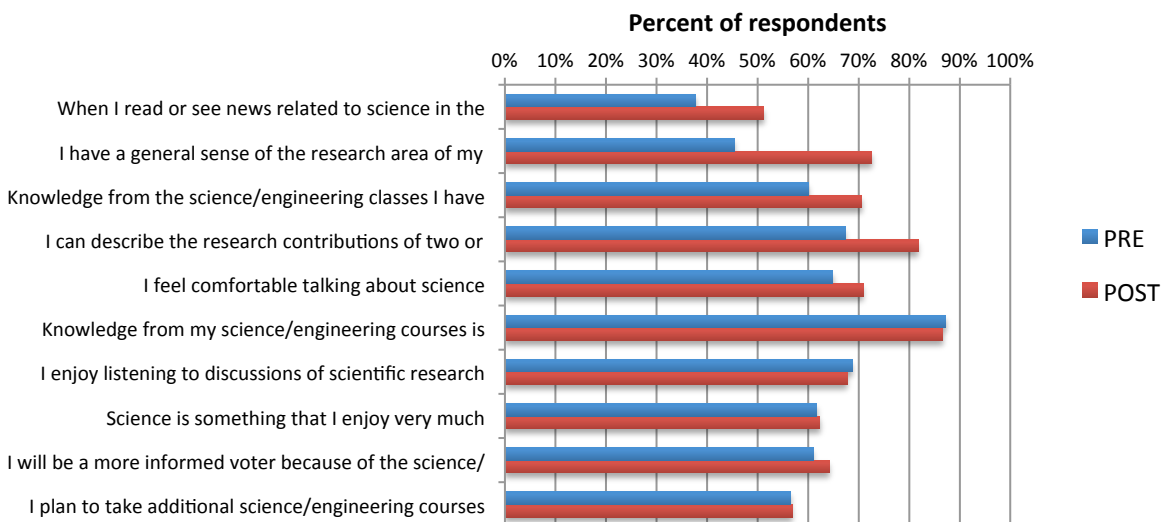
² ABET: <http://www.abet.org/>

The Council offers financial resources to faculty developing new and enhancing existing ST-designated courses. During the 2013-2014 academic year, the Council awarded 10 grants to faculty from Astrophysical Science, Ecology and Evolutionary Biology, Engineering, Geosciences, and Physics. Two of the grants were made in co-sponsorship with the 250th Fund award.

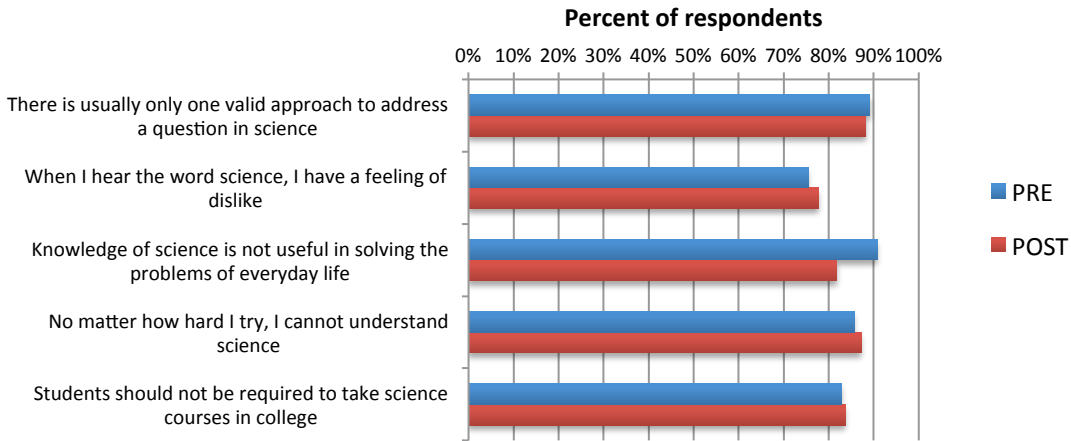
In addition to financial resources and guiding course goals, the Council’s four Professional Specialists are available to assist faculty with the enhancement of existing ST-designated courses and the development of new ST-designated courses. Each Professional Specialist has a terminal degree in a STEM field and additional preparation in student-active pedagogy. Throughout the 2013-2014 academic year, the Professional Specialists supported 22 ST-designated courses. Case studies of their work are provided in Appendix C.

The Council administers a survey to understand the extent to which students’ attitudes and beliefs towards science change. The survey is administered at the start and end of each semester to students enrolled in the courses identified as being aligned with the Science and Engineering Education Initiative (see Appendix B). The overall results for the attitudes surveys administered in the fall and spring of the 2013-2014 academic year follow. Individual course results vary considerably. Overall, we were interested in the movement of indicators that reflected students’ confidence in their scientific/engineering abilities and their personal behaviors related to science/engineering. To ensure that students are reading the survey carefully, some statements are written with a positive sentiment, and we hope to see improvements in the number of students agreeing or strongly agreeing with the statements. Other statements are written with a negative sentiment, and we hope to see an increase in the number of students who disagree or strongly disagree. In all graphs, positive results are closer to 100%.

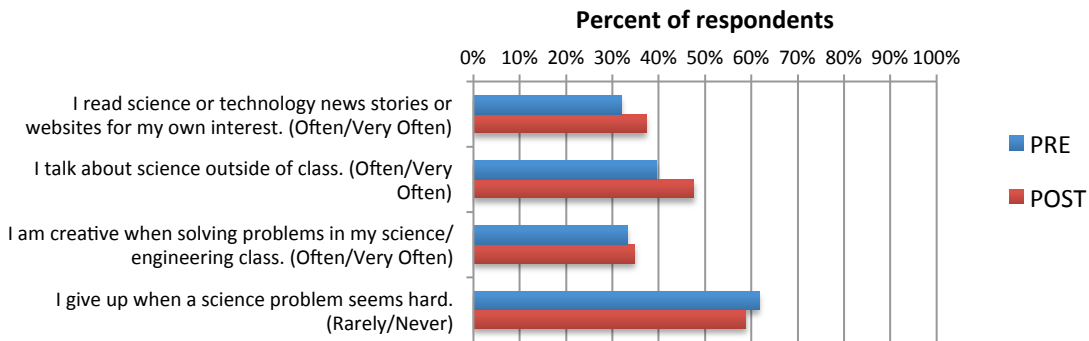
Fall 2013 attitudes (agree or strongly agree), n=313



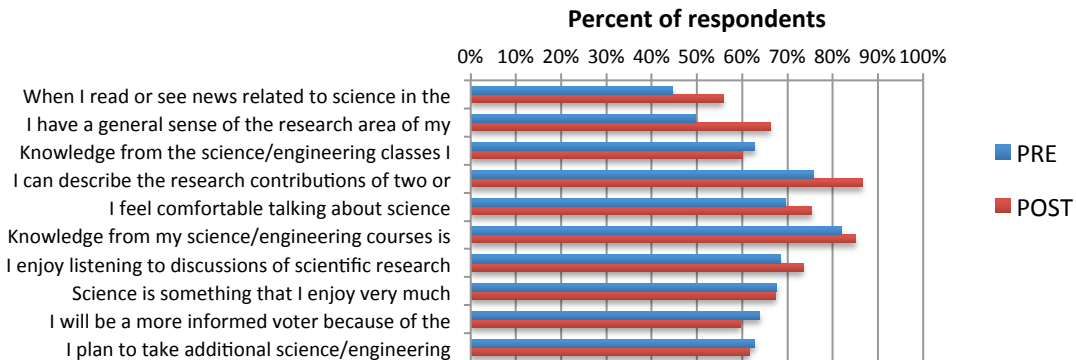
Fall 2013 attitudes (disagree or strongly disagree), n=313



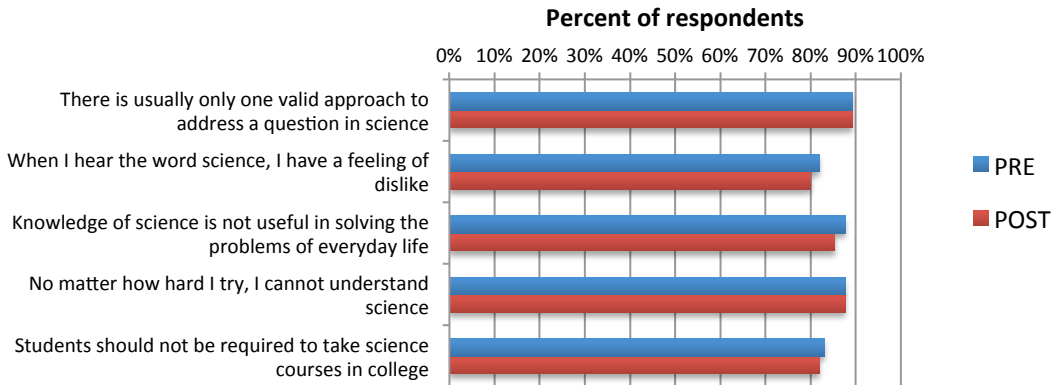
Fall 2013 behaviors, n=313



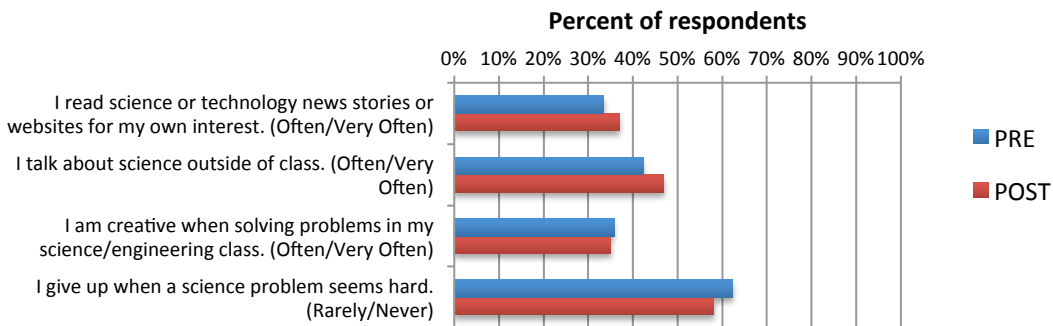
Spring 2014 attitudes (agree or strongly agree), n=260



Spring 2014 attitudes (disagree or strongly disagree), n=260

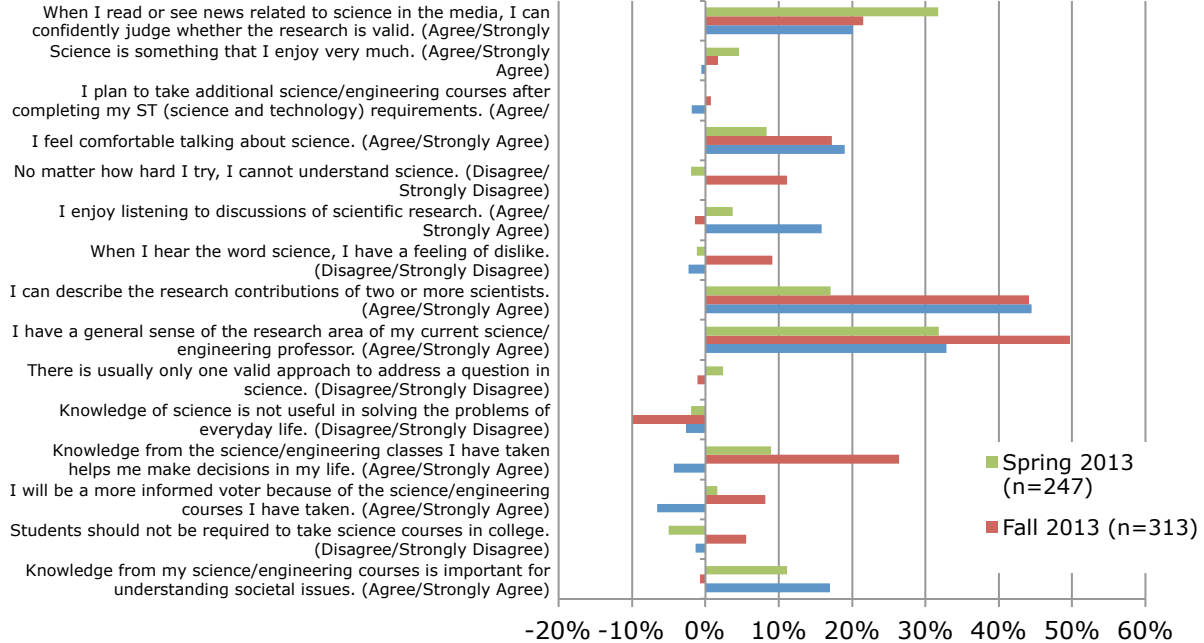


Spring 2014 behaviors, n=260

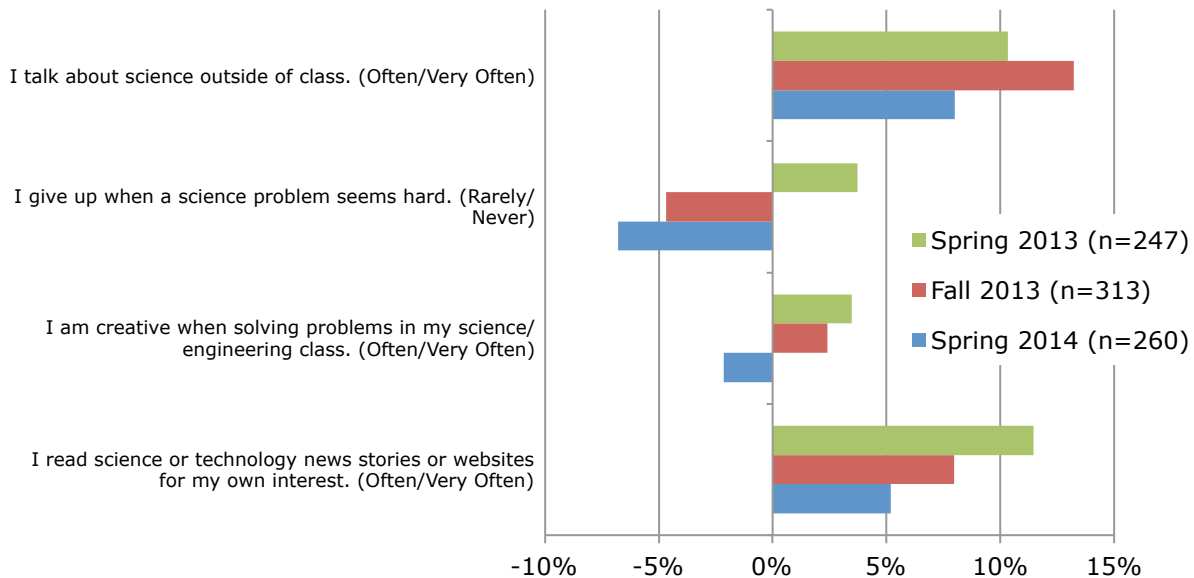


The last graph summarizes three semesters of attitude results. Positive values are calculated as $\frac{\text{post-semester values} - \text{pre-semester values}}{100 - \text{pre-semester values}}$, or in other words, the improvement normalized by how close the original survey values were to 100% (e.g., a 5% improvement from a starting point of 90% would be normalized to 50%, whereas the same improvement starting at 75% would be just 20%). Negative values are calculated as $\frac{\text{post-semester values} - \text{pre-semester values}}{\text{pre-semester values}}$, or in other words, the improvement normalized by how close the original survey values were to 0% (e.g., a 5% decrease from a starting point of 90% would be normalized to -5.6%, whereas the same decrease starting at 75% would be 6.7%).

Normalized pre-post change attitude data



Normalized pre-post change behavior data



Consistently across semesters, we see improvements in students' confidence in judging science in popular media and in recognizing the research interests and contributions of scientists/engineers. Students also show an increase in their frequency of reading and discussing science/engineering outside of class. Other categories may show smaller improvements or inconsistent results. In general, the positive gains are more prevalent. Only one statement shows consistently negative change

(Knowledge of science is not useful in solving the problems of everyday life), but this may be a case of students misreading the statement since the results are inconsistent with similar statements written with a positive sentiment. In general, CST is pleased with the improvements in students' attitudes and behaviors across the semester in which they take ST courses.

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 2013-2014 academic year, two research projects were designed and implemented. Data collection and analysis will continue for several academic years. The following paragraphs describe each of the two current projects.

FSI: 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 primarily use quantitative data to draw conclusions. The voices of the summer bridge participants, who are often first-generation, low-income students, are missing from the literature. To begin to fill these gaps in the literature, the Council 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 quantitative reasoning (QR) course 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. As such, the CST is conducting an in-depth, mixed-methods case study on the FSI. Four primary sets of data will be collected and analyzed: (1) longitudinal interviews with students, (2) classroom observations of the "Problem Solving in Mathematics" course, (3) the FSI pre- and post-questionnaires, and (4) the Class of 2018 Freshman Survey and 2015 and 2016 Enrolled Student Surveys from the Office of Institutional Research.

Physics 103/104: In an effort to enhance the traditional calculus-based introductory physics course, a teaching experiment was undertaken in Physics 103/104 during the 2013-2014 academic year. Specifically, Dr. Katerina Visnjic utilized the Investigative Science Learning Environment (ISLE) curriculum in her labs, while the other sections maintained the labs and pedagogy of previous years. The two key features of the ISLE curriculum include involving students in the development of their own ideas and encouraging students to represent physical process in multiple ways, thus helping them develop productive representations for qualitative reasoning and for problem solving. The Council was invited to explore the cognitive and affective gains for students in Dr. Visnjic's lab. As such, the questions guiding

the CST study are: *As described by the students, what were the PHY 103/104 course goals? How do students describe the ISLE and traditional labs? To what extent did students relate the physics concepts and procedural skills acquired in PHY 103/104 to their everyday lives?* A pilot study began in spring 2014 and will continue into the 2014-2015 academic year. Preliminary findings from the pilot study were presented at the American Association of Physics Teachers 2014 Summer meeting.

IV. Women in STEM Panel and Academic Expo

In welcoming the Class of 2017, the Council on Science and Technology hosted the annual Women in STEM Panel and participated in the Academic Expo during Freshmen Orientation. The Women in STEM Panel was moderated by the Council Director, Prof. Naomi Leonard (Mechanical and Aerospace Engineering). Panel participants included: Abby Doyle (Chemistry), Danelle Davenport (Molecular Biology), Rebecca Fiebrink (Computer Science), and Natalie Saenz and Elizabeth Yang (Women in Science Colloquium student representatives). During the Academic Expo, members of the Council staff greeted students, shared information, and answered questions.

V. Evinin Lectures

The Evinin Lectures were established with a gift from Anthony B. Evinin 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 three Evinin Lectures during the 2013-2014 academic year:

- On October 2nd, 2013, **John Maeda**, former President of Rhode Island School of Design, presented *STEM to STEAM: The Meaning of Innovation*. In the current moment of economic uncertainty, every economy is taking stock and once again turning to innovation as the silver bullet that will guide us forward. Yet in the eyes of many leaders, innovation seems tightly coupled with Science, Technology, Engineering, and Math -- the STEM subjects. Maeda posits that we need to add "Art" to turn STEM into STEAM. Through his experiences as president of the US's leading art and design college, Maeda argues that the critical thinking, critical making and creative leadership which is embodied at RISD can lead us to an enlightened form of innovation where art, design, technology, and business meet. During his talk, Maeda shared lessons from his journey as an artist-technologist-professor turned president to reveal a new model of leadership for the next generation of leaders. The lecture was co-sponsored by the Lewis Center for the Arts and the School of Engineering and Applied Science.
- On October 14, 2013, **John Bravman**, President of Bucknell University, presented *Intellectual Property and Courtroom Science: It's Not CSI*. Movies across a broad range, from serious dramas such as "Presumed Innocent" to farcical comedies such "My Cousin Vinny," along with hit television series such "Crime Scene Investigator" and "Law and Order," have introduced millions to some version of science in the courtroom. But whereas dramatic versions of judicial proceedings feature suspenseful and even thrilling depictions of last-second discoveries, "ah-

hah” moments, and “gotcha” testimony, the real world of intellectual property lawsuits is very different, and offers a distinct view of science in service of the law. There are rarely any surprises...just some very skillful and usually very smart people engaged in highly formalized intellectual combat, with millions and sometimes even billions of dollars at stake. This talk, based on almost fifteen years of service as an “Expert Witness” and some fifty legal proceedings, took attendees inside one area of the law that seems to be growing almost without bounds, and which is especially important in a “knowledge economy.”

- On April 21, 2014, **Keith Devlin**, Stanford Professor and Princeton Visiting Professor of Mathematics, presented *Leonardo and Steve: The Young Genius Who Beat Apple to Market by 800 Years*. The first personal computing revolution took place not in Silicon Valley in the 1980s but in Pisa in the 13th Century. The medieval counterpart to Steve Jobs was a young Italian called Leonardo, better known today by the nickname Fibonacci. Thanks to a recently discovered manuscript in a library in Florence, the story of how this little known genius came to launch the modern commercial world can now be told. The lecture was co-sponsored by the McGraw Center for Teaching and Learning.

VI. Co-Curricular and Informal Learning Experiences

With the intent of promoting and celebrating the role of STEM in society, the Council supported the following co-curricular or informal learning experiences:

- In co-sponsorship with the Keller Center for Innovation in Engineering Education, the Council supported two undergraduate students (a computer science major and a music major) for an informal learning opportunity with Jeff Snyder (Music Department). The purpose of the project was to explore how hardware and software design can relate to the arts and culture. The students worked directly on the development and release of a new electronic wind instrument for professional musical performance. The students worked closely with the case study users (five professional musicians) over the summer to understand the needs of performers and then used their feedback to guide development. The goal of the instrument is to appeal to musicians from multiple genres of music, so gaining an understanding of the needs of these different musical cultures was important to the process.
- The Council supported the annual Art of Science exhibit. As part of our engagement, the following blog post was published: http://www.wired.com/2014/07/art-of-science-empzeal/?utm_source=hootsuite&utm_campaign=hootsuite. Several other media outlets published articles on the event. For example, see <http://www.smithsonianmag.com/science-nature/princeton-university-celebrates-the-art-of-science-71324296/?no-ist>.
- The Council staff assisted with the planning and implementation of the annual Holiday Science Lecture. The 2013 lecture told the story of science and engineering within the theme “Faster than the blink of an eye.” Families were introduced to some features of how we learn about the world using high-speed imaging.

- The Council staff facilitated a workshop for the Future Leaders Institute for Girls in Edgewater Park, NJ. Workshop participants in exploring a career in STEM. The active workshop engaged the participants in an exciting engineering challenge.
- The Council supported Innovation Magazine in establishing the Innovation Journal. Partnering with Harvard, Oxford, Stanford, Duke, Cambridge, and others, Innovation is creating the world's first-ever undergraduate-led intercollegiate science journal.

VII. Conferences, Committees & Presentations

Council faculty and staff engaged with the Princeton University community by serving on relevant committees. For example, Dr. Catherine Riihimaki served as a Staff Representative to the Council on the Princeton University Community (CPUC). She served on the CPUC Executive Committee. Also, members of the Council are invited to consult with various groups and committees across campus. For example, Dr. Jaclyn Schwalm consulted with the committee charged with reviewing and improving the required MOL curriculum. These contributions were included in the report from this committee to the MOL Department, which proposed specific changes to the curriculum that will be implemented moving forward.

A number of Council faculty and staff 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 Council. A few examples of conference attendance and presentations are as follows:

- National Academies Northeast Summer Institute on Undergraduate Education: Members of the Council attended this week-long workshop, dedicated to helping college and university faculty develop their skill in student-active pedagogy. Discussions of current research, assessment and evaluation, and diversity are included throughout the workshop, and faculty develop and share instructional materials to be implemented when they return to their respective institutions.
- American Educational Research Association Annual Meeting: In April of 2014, 3 of our staff members attended the AERA Annual Meeting, held in Philadelphia, PA. This large meeting, allowed these staff members to be immersed in the relevant educational research, as well as to network with a variety of researchers. It also allowed these staff members to prepare to present their work at future AERA meetings.
- Catherine Riihimaki presented Riihimaki, C. A., Schwalm, J. A., Sealfon, C. D., and Leonard, N. E. (2013), *Lessons from the Princeton Science and Engineering Education Initiative: assessing science and technology literacy across the campus*, *Geological Society of America, Fall National Meeting, Abstracts with Program*.
- Aatish Bhatia, Evelyn Laffey and Carolyn Sealfon presented *The Princeton University Council on Science and Technology* at the AAU STEM Education Initiative Networking Conference in Washington, DC. The conference provided a venue for AAU member institutions to learn about the newly launched STEM Education Initiative and share best practices.

Appendix A – ST Course Goals

Disciplinary Core Ideas:

- Develop robust understanding of key STEM concepts and relationships

Scientific Practices

- Identify a scientific question or hypothesis
 - Analyze background information on the question or hypothesis
- Engage in scientific thinking
 - Identify key variables in a system and develop an understanding of their relationships
 - Collect and analyze data to test hypothesis or answer question
 - Understand and explain uncertainty in data and assumptions in analysis
 - Assess credibility and implications of the data and/or methods
 - Work collaboratively to develop and evaluate evidence-based models of underlying phenomena

Engineering Practices

- Explore a societal need or applied science/mathematics problem
 - Research the problem and its challenges
 - Analyze current context in which the societal need or problem exists
- Engage in engineering thinking
 - Explore the mathematical and scientific tools to address challenges
 - Identify key variables in a system and develop an understanding of their relationships
 - Work collaboratively to generate/explore multiple divergent solutions to a design problem
 - Conduct experiments and/or analysis to systematically evaluate the performance of design alternatives
 - Continuously redesign /iterate solution based on evaluation

Communicate STEM Ideas

- Communicate ideas in oral, written and/or graphical form
- Critically assess the credibility of information from a variety of sources
- Develop facility in communicating STEM ideas to a diverse audience

Societal Applications of STEM

- Recognize and understand relevance of STEM issues to society
- Incorporate STEM understanding and resources into social, economic, personal or political decisions

Attitudes Towards STEM

- Appreciate the creativity and excitement of the STEM enterprise
- Connect the work of STEM professionals to everyday life
- Demonstrate confidence in learning/applying STEM concepts
- Exhibit interest in continued learning of STEM ideas

Appendix B – ST-Designated Courses that Aligned with the Science and Engineering Education Initiative

Fall 2013 – 2014

ANT 215 Human Adaptation (STL)

CEE 102B Engineering in the Modern World (STL)

EEB/MOL 211 Life on Earth: Chaos and Clockwork of Biological Design (STL)

FRS 115 Agriculture, Food and the Environment (STL)

GEO/ENV 102B Climate: Past, Present, and Future (STL)

MOL/STC 101B From DNA to Human Complexity (STL)

PHY/STC 115B Physics for Future Leaders (STL)

PSY 101 Introduction to Psychology (STL)

PHY 101 Introductory Physics I (STL)

AST 205 Planets in the Universe (STN)

CEE 334/WWS 452/ENV 334/WWS 455 Global Environmental Issues (STN)

ENV 201A Fundamentals of Environmental Studies: Population, Land Use, Biodiversity, and Energy (STN)

ENV 304/ECO 328/EEB 304/WWS 455 Disease Ecology, Economics, and Policy (STN)

ENV 343 Climate Change and Extreme Weather (STN)

FRS 111 Water: Keystone for Sustainable Development (STN)

FRS 119 Human Genomes & Future of Human Beings (STN)

FRS 125 Global Environmental Change: Science/Tech/Policy (STN)

FRS 133 Materials World (STN)

GEO/ENV 102A Climate: Past, Present, and Future (STN)

GEO/AST/EEB/CHM 255A Life in the Universe (STN)

MAE/EGR/CBE/ENE 228 Energy Solutions for the Next Century (STN)

NEU/PSY 258 Fundamentals of Neuroscience (STN)

PHY 115 Physics for Future Leaders (STN)

Spring 2014

CEE 262B Structures and the Urban Environment (STL)

ENV 240 Environmental Challenges and Sustainable Solutions (STL)

FRS 106 Art and Science of Motorcycle Design (STL)

GEO 103 Natural Disasters (STL)

NEU 101 Neuroscience and Everyday Life (STL)

MOL 214 Intro to Cellular and Molecular Biology (STL)

PHY 102 Introductory Physics II (STL)

PSY 101 Introduction to Psychology (STL)

EEB 301 Evolution and the Behavior of the Sexes (STN)

EEB 311A Animal Behavior (STN)

ENE 202 Designing Sustainable Systems: Applying the Science of Sustainability to Address Global Change (STN)

FRS 108 Lights, Camera, Action (STN)

FRS 134 Emerging Micro- and Nano-Engineered Technology (STN)

FRS 148 Drug Discovery: From Snake Venoms to Medicines (STN)

FRS 156 Exotic Quantum States of Matter (STN)

FRS 158 Why Global Warming is Controversial (STN)

Mol 205 Genes, Health and Society (STN)

WWS 353 Science and Global Security: From Nuclear Weapons to Cyberwarfare (STN)

Appendix C – Case Studies of Courses Supported by CST Professional Specialists

Dr. Aatish Bhatia worked with several courses during the 2013 – 2014 academic year. Highlights from two of those courses are described in the following case studies.

CEE 262: Structures in the Urban Environment, taught by Prof. Maria Garlock from CEE.

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. CST provided summer support and guidance for two undergraduate students who constructed interactive demonstrations highlighting principles of resonance, earthquake and wind resistance in buildings, and developed an open-ended bridge design competition that uses simulation software to introduce students to principles of optimization and aesthetic exploration. CST has also been involved in enhancing the active learning exercises (including clicker questions and interactive lecture demonstrations, some highlighted here: <http://www.princeton.edu/main/news/archive/S39/99/20182/>), and is a recipient of a cross-institutional NSF IUUSE award to enhance, assess and disseminate this course on a wide scale.

FRS 134: Emerging Micro- and Nano- Engineered Technologies, taught by Dr. Janine Nunes

Students in this course are exposed to a broad survey of concepts in science and engineering through case studies of emerging micro-technologies with societal applications such as drug delivery, point of care diagnostics, and health monitoring. CST worked with this course to incorporate blogging assignments and to highlight the elements of effective science blogging. Students iteratively created blog posts to explain and highlight current research in this field. Through a peer-review process via blog comments, the students also provided detailed feedback and personal responses to each others' work. CST also provided assistance in designing and incorporating investigative mini-labs, where the students worked on open-ended tasks such as developing and optimizing a capacitive touch sensor.

Dr. Catherine Riihimaki worked with several courses during the 2013 – 2014 academic year. Highlights from four of those courses are described in the following case studies.

ENV201: The Fundamentals of Environmental Studies: Population, Land Use, Biodiversity, and Energy, taught by Prof. David Wilcove from WWS/EEB and Prof. Kelly Caylor from CEE, is aimed at students interested in the combination of environmental science and policy. In Fall 2013, CST facilitated several revisions to the course to improve student engagement in lecture and precept, to build critical skills for analyzing environmental issues in the news, and to increase feedback to the students on their progress toward learning skills and concepts. Specific changes included

- 1) Experimentation with more in-class questions, discussions, and activities, such as debating organic versus conventional agriculture based on a Stanford University study and exploring global environmental data using Google Public Data Viewer (<http://www.google.com/publicdata/directory>);
- 2) Development of a new precept activities based on the questions: what are the important concepts this week, what concepts will they struggle with and therefore need more time to digest, and what specific data can we have them examine that will help them deal with the concepts in a rigorous way and that they can use to demonstrate deep understanding; data have included campus-specific data on energy consumption (see the energy project description), personal data from their lives (e.g., descriptions of their diets from the few days before precept), data collected in a whole-class tragedy-of-the-commons game, and data sets from homework readings;

- 3) Development and assignment of two new precept projects, with the students looking at energy usage on Princeton's campus and dietary choices of conventional versus organic versions of specific food items;
- 4) Creation of two mid-semester evaluations for students to provide feedback on the two halves of the course; and
- 5) Creation of a survey of the class to reflect on how this course has impacted their optimism about our ability to solve environmental issues discussed in the course.

CST teaching specialist Catherine Riihimaki also developed and taught a full semester of new lab exercises, with a particular emphasis on modeling and computation, two topics of critical importance in topics discussed in lecture but previously ignored in lab. The outcomes of these changes were positive, with course evaluation scores significantly higher than in Fall 2012, with a particular jump in the evaluations from the ENV201B students (i.e., the students who take the optional lab).

MAT175: Mathematics for Economics/Life Sciences, taught by Prof. Jennifer Johnson and Prof. Hanne Vlaeminck is a course aimed at students who wish to have a single, more directed math course aimed specifically at future economists or life scientists. In past offerings, students have been concerned about unclear expectations and harsh exam grading. CST worked with the instructors to 1) clarify and communicate learning goals for the course; 2) increase student engagement in homework by increasing the contribution of problem sets to the final grade percentage; and 3) create stronger alignment between the difficulty of homework and exams. Student evaluations scores on Assessment noticeably improved, a reflection of the emphasis on more fair assessment practices. The other evaluation scores were similar to previous class offerings, and may therefore be the focus of course revisions in 2014-2015.

GEO103: Natural Disasters, taught by Allan Rubin and Laurel Goodell (labs), is an STL course that attracts a diverse set of students interested in hazards such as earthquakes, volcanic eruptions, floods, and climate change. Course enrollment increased significantly in Spring 2014, from 27 to 73 students. CST involvement in the course likely contributed to this enrollment increase, because changes facilitated by CST in Spring 2013 led to positive student evaluations. The primary change in Spring 2013 was to incorporate weekly readings of natural-disaster case studies from the popular media, rather than solely relying on the textbook for outside readings. In Spring 2014, we built on the success of the previous offering by continuing the current-event readings with some additions. We also increased student engagement in lecture by fostering whole-class discussions prompted by clicker questions and by developing worksheet activities for students to discuss and complete in small groups. Course evaluations dipped slightly from the previous year, perhaps the result of the rapid increase in class size, but remain higher than the evaluations prior to CST involvement.

ENE202: Designing Sustainable Systems - Applying the Science of Sustainability to Address Global Change, taught by Prof. Forrest Meggers from ARC and Andlinger Center, was a new course in Spring 2013. It combines environmental science and design concepts to help students develop creative solutions to environmental problems such as transportation inefficiencies, excess waste production, and overuse of electricity. CST helped Dr. Meggers develop learning goals and teaching strategies for the class, and administered a mid-semester survey to determine how the students were responding to the course. Student evaluations indicate some positive aspects of the course, but also room for improvement in aligning lectures and assignments with learning goals. CST will continue to work with Dr. Meggers to increase enrollment and improve student outcomes.

Dr. Jaclyn Schwalm worked with several courses during the 2013 – 2014 academic year. Highlights from two of those courses are described in the following case studies.

MOL101: From DNA to Human Complexity taught by Profs. Eric Wieschhaus and Heather Thieringer
In the 2012-2013 academic year, in collaboration with one of our staff members, the instructors of the MOL101 course, which is composed almost exclusively of students majoring in the humanities or social sciences, began to incorporate more student-active pedagogy into the course. In the 2013-2014 academic year, this work was continued and expanded.

The course was taught in the Frist Campus Center Multipurpose Room, which allowed groups of students to sit at round tables and work collaboratively throughout the course. The flat classroom space also allowed instructors and assistants in instruction to circulate, working with students in small groups during these collaborative activities. In addition, a student-response system was used throughout the course, allowing the students to text in their answers to questions to check their own understanding, and allowing the instructors to determine whether students were understanding the material in real-time. The course will again be taught in this room during the 2014-2015 academic year, and the use of student-response systems and collaborative activities will be continued and expanded.

In addition to the use of collaborative work and student-response systems in class throughout the course, learning goals were incorporated into the course and students were asked to complete pre- and post-class assignments. The learning goals helped the students to have a better understanding of the course expectations, and the assignments helped the students to understand and review the concepts taught in class, as well as helped the instructors to identify concepts about which students were particularly confused. These areas of confusion could then be addressed in class. Student performance on these assignments was highly correlated with their performance on exams, suggesting that the assignments were accomplishing their intended purpose.

A research project was also undertaken to determine the impact of the MOL101 course on students' understanding of biological concepts, as well as the impact of specific lectures and activities on the students' understanding and attitudes about those topics. The results of this research are promising, suggesting that students' understanding of biological concepts and their attitudes about their abilities are improved from the beginning to the end of the course. This research will be continued in the course the upcoming year.

MOL/EEB 214: Introduction o Cellular and Molecular Biology taught by Profs. Heather Thieringer, Daniel Notterman, Elizabeth Gavis, and Anthony Ambrosini
In the 2013-2014 academic year, one of our CST staff members began working with this course, which is the pathway course for the MOL major, but has historically been made up of 30% or more non-majors. As part of the initial work with the course, learning goals were incorporated for the first time. A student-response system was used, and the staff member worked with the instructors to ensure that the questions were challenging and aligned with the learning goals. In addition, a mid-semester evaluation was provided, so that students could provide feedback midway through the course. This allowed the instructors to better understand the student perspective and to address student concerns. This work will be continued in the coming academic year, as our staff member will be working with the course as an appointed lecturer in the MOL Department.

Dr. Carolyn Sealfon worked with several courses during the 2013 – 2014 academic year. Highlights from four of those courses are described in the following case studies.

PHY 115: Physics for Future Leaders, taught by Prof. Paul Steinhardt

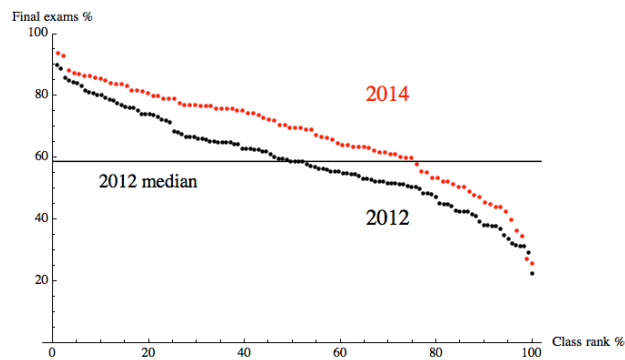
Goal: Designing assignments and activities that increase transfer of learning (e.g., to everyday life). Seeking to combine virtues of the 2011 final project (making comparisons among scientific projects in a realistic roleplaying scenario) and the 2012 final project (applying PHY 115 concepts to evaluate technologies directly relevant to students' lives), we assigned students to evaluate and compare projects from crowdfunding websites (such as Kickstarter). Each student was assigned two inventions from an actual crowdfunding site, and provided with several guiding questions (qualitative and quantitative) to apply their learning from PHY 115 to evaluate and compare the feasibility of the projects. They were then asked to find a third crowdsourcing project on their own that they thought was better than the other two, and come up with their own questions to apply PHY 115 material to evaluate its feasibility.

PHY 102: Introductory Physics taught by Prof. Steve Gubser

Goal: Increasing professor-student feedback through formative assessment activities

Prof. Gubser created weekly pre-class video lectures covering material from each week's assigned chapter, which he posted on Coursera. We interspersed each video lecture with 5-10 conceptual and quantitative multiple-choice questions, based on physics education research where possible, for students to check their understanding and for Prof. Gubser to see what students were getting wrong before lecture. Lectures were primarily focused on interactive demonstrations, for which students would use clickers to make predictions about outcomes (since research shows that this enhances student learning from demonstrations). Significant time in precepts was devoted to students working in assigned groups through packets of physics problems.

Prof. Gubser gave a final exam that was roughly isomorphic to an exam he gave two years ago, and found a significant gain in student learning:



Comparison of exam scores, courtesy of Prof. Gubser

We estimate the error due to differences in graders to be about 3 points, which is much less than the overall difference in exam scores of about 9 points.

PHY 103-104: General Physics, Select Precepts/Labs taught by Dr. Katerina Visnjic

Goal: Changing the classroom dynamic from teacher-centered to student-centered

To assist with piloting ISLE (Investigative Science Learning Environment) labs in PHY 103-104, we held weekly meetings with the graduate Assistants in Instruction for the experimental sections. We discussed articles or results from physics education research about common student challenges with the

coming week's material and strategies to address them, as well as reflected on the past week, discussed what went well, and brainstormed solutions to unexpected challenges that arose.