Council on Science & Technology 2011-2012

Bonnie Bassler, Chair  Molecular Biology

Executive Committee

Manjul Bhargava  Mathematics
Naomi Leonard  Mechanical & Aerospace Engineering
Sharad Malik  Electrical Engineering
James Richardson  English & Creative Writing
Paul Steinhardt  Physics
Howard Stone  Mechanical & Aerospace Engineering
Emily Thompson  History

Sit-Withs

Clayton Marsh  Office of the Dean of the College
Carol Porter  McGraw Center for Teaching and Learning

Council Staff

Els Paine  Associate Director
Carolyn Sealfon  Associate Director, Science Education
I. New Direction and New Staff
II. General Education Oversight
III. New STL and STN Courses
IV. ST Course Transformation
V. Council Events and Awards
VI. Assessment
VII. Strategic Planning and Infrastructure
I. New Direction

In the Spring of 2010 the Council on Science and Technology, led by chair Professor Bonnie Bassler, published a white paper calling for a change to the Science & Technology (ST) distribution requirements for Princeton undergraduates. The white paper outlined the Science and Engineering Education Initiative (SEEI). Rather than requiring two lab courses for all students, the Council advocated reducing the lab requirement to one lab course (STL), but raising the bar for ST courses to ensure that students left those courses with particular skills and a certain level of scientific literacy. In addition the Council advocated creating a new category of science electives without a lab (STN). Students could take two STLs or one STL and one STN to complete their ST requirement. These STN classes would contain significant (>50%) core science or engineering learning, but would also have a strong emphasis on the application of that science or engineering to societal issues.

The motivations for the Science and Engineering Initiative were several. First, the 2008 senior exit survey showed that only 30% of seniors felt that being able to identify the role of science and technology in society was “essential” in their lives (Exhibit A). In addition, there was anecdotal information that to fulfill their science requirements, students were gravitating toward the least demanding courses. Lastly, students concentrating in the humanities and social sciences were rarely taking more than the minimum 2 science classes, in part because of the time commitment for the labs and perhaps because of the lack of perceived relevance. The Council’s mission, in line with the University’s, is to ensure that our graduates understand the relevance of science and technology in their lives. In addition, we aim to graduate citizens, voters, and leaders who can intelligently assess the most pressing topics facing society. Finally, the Council seeks to create exciting new science electives for all majors that will increase students’ curiosity and appreciation for science and technology in their lives.
The faculty voted to approve the proposed changes in the ST requirements in spring 2010. The funding for the SEEI came from a reallocation of current CST funds. The existing post-doc program was discontinued. The income from the CST endowment is being used in part to employ a full-time administrator for the Council and 3 teaching specialists. The teaching specialists were deemed by the administration and faculty to be essential for the initiative to succeed and the best way to enact fundamental change: one to one, one faculty member and course at a time. The teaching specialists are PhDs in their respective fields (Physics, Environmental Science and Engineering) with experience teaching at the undergraduate level and a demonstrated interest in pedagogy. The role of the teaching specialists is to help faculty develop new ST courses, and at the same time introduce interactive research-based teaching methods into these courses. This model is similar to Carl Wieman’s model of teaching fellows implemented at the University of British Columbia. Ensuring that the ST courses employ the most effective teaching methods should result in higher engagement and learning in the classroom.
New Staff

In June 2011, The Council hired Carolyn Sealfon as the first professional specialist. Dr. Sealfon is a Physics professor with a BA from Cornell and PhD in Physics from the University of Pennsylvania, with 5 years of experience teaching undergraduates and a strong pedagogical background. The Council hired another professional specialist with a similar background in Environmental Science who will join the Council staff in September, 2012. Recruiting of the Engineering Teaching Specialist is ongoing.

In December 2011, hired a new administrator, Els Paine. Els holds an AB from Princeton in Molecular Biology, an MBA from Wharton, and has 20 years of managerial experience.

II. General Education Oversight

The Council continues to have oversight of the ST courses in the General Education requirements for undergraduates. As part of the new Initiative, the Council developed a list of Essential Skills for STL and STN courses, which will guide development of new courses and aide discussion of existing courses (Exhibit B). The professional specialists will reference the goals as they work with faculty to help shape new and existing courses to meet the ideals of the new STL and STN courses.

The Dean of the College noted that there were few QR courses for non-STEM students to fulfill their requirement. This is in part because, with the advent of the new STN category, some QR courses were reclassified as STNs. In turn, the Council received requests to fund QR courses and noted an unclear divide between QR and ST when defining the Essentials Skills for ST courses. The solution proposed by the Dean of the College, to be proposed to the Committee on the Course of Study, is to allow some courses to be co-listed as ST and QR. In AY2012-2013, the Council will assist the Dean of the College by defining the characteristics of an ST course vs. a QR course, and identify those STN courses that are good candidates for co-listing as QR. This action may provide an immediate increase in the number of QR courses without additional funding, and reflects the changing nature of the disciplines.
Working with the Office of the Registrar, the Council ensured that new and existing ST and QR courses appropriate for students concentrating in humanities and social science are easily identified, through a new menu item in Course Offerings “STL, STN and QR Courses for General Education.”

New Menu Item in Course Offerings

**Fall 2012-2013 STL, STN and QR Courses for General Education**

Recognizing that our future leaders and citizens must be scientifically literate, Princeton University established the Council on Science and Technology to promote the development of courses for students concentrating in the humanities and social sciences that will advance their understanding of science and technology, particularly as they impact society. To assist students in their efforts to identify such courses, the Council provides a list of the STL, STN, and QR courses for Fall 2012-2013 that do not carry significant prerequisites in engineering or the natural sciences. Please be sure to read the full description and any prerequisites or requirements in Course Offerings. A complete list of STL, STN and QR courses may be retrieved by searching with the Distribution Area dropdown in Course Offerings.

**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
- GEO 102B Climate: Past, Present, and Future
- GEO 255B Life in the Universe
- MOL 101B From DNA to Human Complexity
- PHY 101 Introductory Physics I
- PHY 115B Future Physics
- PSY 101 Introduction to Psychology

**STN Courses – Science and Technology without Lab**
- AST 201 Mapping the Universe
- AST 205 Planets in the Universe
- CEE 334 Global Environmental Issues
- ENV 201A Fundamentals of Environmental Studies: Population, Land Use, Biodiversity, and Energy
- ENV 304 Disease Ecology, Economics, and Policy
- GEO 102A Climate: Past, Present, and Future
- GEO 255A Life in the Universe
- LIN 370 Brainwaves in Language Research
- MAE 228 Energy Solutions for the Next Century
- MAE 244 Introduction to Biomedical Innovation and Global Health
- NEU 258 Fundamentals of Neuroscience
- PHY 115A Future Physics

**QR Courses – Quantitative Reasoning**
- COS 109 Computers in Our World
- GEO 197 Environmental Decision Making
- GEO 415 Introduction to Atmospheric Sciences
- MAT 100 Precalculus / Prestatistics
- MAT 103 Calculus
- POL 345 Quantitative Analysis and Politics
- PSY 251 Quantitative Methods
- SOC 301 Sociological Research Methods
- WWS 332 Quantitative Analysis for Public Policy
III. New STN and STL Courses

The Council developed a “working list” of potential new ST courses through a direct request to science and engineering faculty, brainstorming by the Council, and working closely with other initiatives aligned with the Council’s goals. The Council identified coincident goals with the requirement for a science policy course in the revised Woodrow Wilson School (WWS) major. The Council worked with the Vice Dean of the WWS to ensure that the caps on the new courses would be sufficiently high to allow both WWS and other students to enroll. The Council’s professional specialists are working with the professors for 2 of these new science policy courses, WWS 350 and WWS 353, so that the courses are aligned with both the WWS and CST goals and may qualify as permanent STNs in 3 years. The Council may also assist in recruiting and funding AIs for these courses to the extent that graduate students are not available or that additional AIs are required for interactive engagement in the classroom.

With IRB approval, the Council administrator interviewed current STL students regarding their attitudes toward science and engineering education and its place in their lives, and asked them for new ST course ideas.

The Council approved 5 new STN designations and 2 new STL designations for AY2012-2013. Three of the new STNs were provisionally approved, so that the professors may have time to incorporate either societal applications, interactive teaching methods or other CST goals by the time the course is reviewed to become a permanent course in 3 years.

New STN designations
AST 205 Planets in the Universe (new course, provisional STN)
LIN 570 Brainwaves in Language Research (new, one-year course)
WWS 496 Disease Ecology, Economics and Policy (revised course)
WWS 350 The Environment – Science and Policy (new course, provisional STN)
WWS 353 Science and Global Security (new course, provisional STN)

New STL designations
AST 255 Life in the Universe (new track)
EGR 194 An Integrated Introduction to Engineering (existing course)
IV. ST Course Transformation

The Council organized a dinner for 20 professors of STL courses to show early pilot assessment results and provide a tutorial on one interactive method. The lively debate and discussion at the dinner resulted in several requests for course-level help with introduction of research-based teaching methods, as well as a request for videotaping for experimentation with flipping the lecture in an STL course.

The Council professional specialist, Carolyn Sealfon, started to develop a “tool kit” of interactive techniques for implementation in the science classroom, through her own experience, researching the education literature, and attending relevant conferences.

Together with the professors, Dr. Sealfon defined learning goals and revised homework and exams to better align with those goals in PHY 115 (STL). She added a lab on uncertainty and introduced more class participation and interaction in lectures. Dr. Sealfon observed MOL BIO 101 (STL) in preparation for transforming the course to include more active participation in Fall 2012.

Dr. Sealfon received endorsements from the chair of the Council and the Dean of the Faculty to attend a summer institute on research-based teaching methods in undergraduate biology at Harvard. Dr. Sealfon attended with one of the lecturers for MOL BIO 101 and MOL BIO 214, and they will use their newfound knowledge to flip lectures and introduce interactive methods when MOL BIO 101 is offered in the fall.

V. Council Events and Awards

The Council organized lunchtime seminars for faculty, staff, graduate students and post-docs given by visiting professors recognized for their exceptional teaching, hosted at the McGraw Center for Teaching and Learning. The topics were Science Literacy (Christopher Impey) and Robotics: Motivation in Education (Christopher Clarke). Council Member Naomi Leonard moderated a panel discussion of female STEM faculty and students for incoming freshmen during orientation. Applications for the Pope Prize were collected by former CST administrator Carol Prevost, and the prize was awarded to Karen Krieb and Madelon Case.
VI. Assessment

Assessment is considered an essential component of any educational endeavor, and justifiably, University administrators and faculty periodically request proof that the SEE Initiative is accomplishing its goals; measuring the impact of the CST work is imperative. The Council piloted an assessment of attitudes towards science and a numeracy test in Fall and Spring STL courses. The Council drafted an RFP and entered discussions with potential partners in assessing the outcomes of the initiative at the course level. With the assistance of the Vice Provost for Institutional Research, the Council inserted questions into both the Freshman and Senior surveys as well.

The first pilot assessment data show student variability across courses in terms of entering numeracy (Exhibit C) and gains in some courses on important attitudes (Exhibit D). The results are informative but by no means conclusive, which is why the Council is seeking the counsel of assessment professionals.
Exhibit C

CST Pre-Test Numeracy Assessment
Overall Percent Correct by Course

<table>
<thead>
<tr>
<th>Course Description</th>
<th>Percent Correct</th>
</tr>
</thead>
<tbody>
<tr>
<td>FRS 127 New Eyes for the World: Photonics (n=16)</td>
<td>90%</td>
</tr>
<tr>
<td>PHY 115 Future Physics (n=43)</td>
<td>88%</td>
</tr>
<tr>
<td>ENV 201B Fundamentals of Environmental Studies (n=46)</td>
<td>87%</td>
</tr>
<tr>
<td>GEO 102B / ENV 102B Climate: Past, Present, and Future (n=22)</td>
<td>87%</td>
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<tr>
<td>PSY 101 Introduction to Psychology (n=87)</td>
<td>86%</td>
</tr>
<tr>
<td>CEE 102B / EGR 102B / MAE 102B Engineering in the Modern World (n=81)</td>
<td>86%</td>
</tr>
<tr>
<td>FRS 101 Signals, Yardsticks, and Tipping Points (n=12)</td>
<td>86%</td>
</tr>
<tr>
<td>ANT 215 / EEB 315 Human Adaptation (n=39)</td>
<td>86%</td>
</tr>
<tr>
<td>MOL 101B From DNA to Human Complexity (n=110)</td>
<td>85%</td>
</tr>
</tbody>
</table>

Source: Fall 2011 CST Assessment in STL Courses for non-STEM students, incomplete tests not included

CST Pre-Test Numeracy Assessment
Overall Percent Correct by Question Number

<table>
<thead>
<tr>
<th>Question Number</th>
<th>Percent Correct</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multiplying Fractions (7)</td>
<td>95%</td>
</tr>
<tr>
<td>Writing Linear Equation (16A)</td>
<td>93%</td>
</tr>
<tr>
<td>Solving Linear Equation (16B)</td>
<td>91%</td>
</tr>
<tr>
<td>Pythagorean (4)</td>
<td>88%</td>
</tr>
<tr>
<td>Cube Root (8)</td>
<td>87%</td>
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<tr>
<td>Histogram (10)</td>
<td>86%</td>
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<tr>
<td>Solving equation (9)</td>
<td>85%</td>
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<tr>
<td>Linear Graph (2)</td>
<td>84%</td>
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<tr>
<td>Volume Reasoning (3)</td>
<td>83%</td>
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<tr>
<td>Proportional Reasoning (11)</td>
<td>82%</td>
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<tr>
<td>Exponential Growth (14)</td>
<td>81%</td>
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<tr>
<td>Estimation (6)</td>
<td>80%</td>
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<tr>
<td>Simplifying exponents (15)</td>
<td>79%</td>
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<tr>
<td>Rate of Change (5)</td>
<td>78%</td>
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<tr>
<td>Probability (13)</td>
<td>77%</td>
</tr>
<tr>
<td>Measurement Agreement (12)</td>
<td>76%</td>
</tr>
</tbody>
</table>

Source: Fall 2011 CST Assessment in STL Courses for non-STEM students, n=466
VII. Strategic Planning and Infrastructure

As the majority of the Council’s activities and expenditures have no established history at the University, the Council chair and administrator, in consultation with the Council, took a number of steps to ensure that the Council and its staff have the physical and financial requirements to achieve their goals, now and in the future. These steps included:

- Creating a simple but functional website for the Council,
- Working with the Office of the Provost to secure office space for the CST professional specialists. Offices for the 2 current specialists were provided in Frist 327, and plans are underway to reconfigure the combined CST and McGraw space to adequately house both departments.
- Working with the Office of the Provost to develop realistic 5-year financial forecasts for the Council’s current and future needs,
Submitting discussion documents to the Office of the Dean of the College and the Office of the Provost on the topic of raising funds for the introduction of interactive teaching methods in introductory courses for science and engineering majors. This topic was addressed in the CST white paper as a future CST goal, but the current mission and resources make this difficult. The Council will take steps in AY2012-2013 to address the question of STEM teaching.

Cementing good working relationships and future plans with other University departments whose goals are closely aligned with the Council’s, specifically the McGraw Center for Teaching and Learning, the Keller Center for Innovation in Engineering Education, the Woodrow Wilson School and Princeton Environmental Institute.

We are confident that with these partners, AY2012-2013 will provide additional exceptional milestones towards our new Initiative and our shared goals with other faculty and administrators of Princeton University.