Improving the Undergraduate STEM Experience

PLENARY SESSION PROCEEDINGS

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INNOVATION THROUGH INSTITUTIONAL INTEGRATION

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National Science Foundation

INNOVATION THROUGH INSTITUTIONAL INTEGRATION

nsf-i3.org/

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The conference was organized by TERC, a not-for-profit education research and development organization based in Cambridge, Massachusetts, as part of a grant from NSF to build an online network for the I³ projects and to disseminate lessons learned.

Participant comments have been paraphrased; they are not exact quotes. The contents of this document do not necessarily reflect the views of TERC, the National Science Foundation, or the organizations of any participants.

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Conference Documentation
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Cover photo: Policies and Processes breakout group

Innovations through Institutional Integration (I³) Goals

- Increase synergy and collaboration across NSF-funded projects and within/between institutions
- Expand and deepen impact, and enhance sustainability
- Broaden participation, attend to transitions across critical educational junctures, and/or provide for more globally engaged workforce
- Promote innovative programming, policies and practices to encourage integration of STEM research and education
- Encourage research on intra- or inter-institutional integration & broader impacts

I³ Conference Goals

The conference was designed to capture and distill best practices and lessons learned from institutions that have demonstrated capacity to create and sustain innovative programs, and offer participants time to learn about those best practices, network with others, and explore future funding opportunities. Collectively, National Science Foundation I³ projects have developed programs that have influenced the student STEM experience, broadened participation, and addressed critical junctures. This conference provided an opportunity to share innovations that have had an impact and have been sustained. In addition to I³ projects, the conference also provided an opportunity to hear from other exemplary programs across the country.

Additional Conference Documentation

Conference vidoes, documentation of breakout sessions, original PowerPoint presentations, posters, background information on speakers and participants, and additional conference materials.

nsf-i3.org/conference/

INTRODUCTION

Joni Falk
Co-Director, Center for School Reform, TERC
PI, Creating a Web Presence for the I^3 Track

Joni Falk welcomes participants, encouraging them to draw on their experience with their Innovation through Institutional Integration (I^3) projects to share what they have learned and what has worked, to identify challenges that still need to be addressed, to actively network with colleagues from other I^3 projects, and to begin to envision and discuss new initiatives and ideas.

This conference was designed to address three overarching questions:

- **The Student Experience**
  What are the innovations that have had a significant impact on transforming the STEM student experience (curricular or extracurricular) for majors or for non-majors? How do we gather effective evidence?
- **Broadening Participation**
  What are the innovations that have had a significant impact on broadening participation in STEM? What is the evidence of effectiveness?
- **Policies and Processes**
  What are the innovative policies or processes that have created cultural change on your campus and have improved STEM teaching and learning? How can we design future programs to collect evidence of effectiveness?

The conference was designed to be participatory and interactive. After an initial plenary session, it is the conference participants who will be talking, sharing, and creating, with four "thought leaders" introducing topics of broad interest and facilitating discussion. The expectation is that participants will benefit most by learning from each other.

The intent is to gather stories of innovations tried so far, to examine whether we have gathered evidence of effectiveness, and address how to design future programs to assure that evidence is gathered.

Creating a Web Presence for the I^3 Track: Joni Falk, PI (left) and Kathryn Hobbs, CoPI

Conference Carryover

I^3 programs include outreach, professional development, programs targeting specific groups of students, and projects that traverse departments and the university at large, creating structural changes up and down the pipeline. I^3 projects were asked to come to this conference as teams, with one administrator and one STEM faculty leader. There is power in that, Falk observes. These teams bring both the STEM expertise and knowledge of what happens in the department and the classroom, and the administrative expertise and the knowledge of interdepartmental concerns and how resources are deployed. One indicator of success for this conference is the degree to which faculty leaders and administrators work together and share new ways of thinking and new ideas as they return to their campuses.

KEYNOTE ADDRESS

Transforming STEM Education: Where Gladly They Will *ALL* Learn

Shirley M. Malcom, Ph.D.
Head of Education and Human Resources Programs,
American Association for the Advancement of Science

> "The need to disentangle is paramount in the way we think about the populations served."
>
> *Shirley Malcom*

Shirley Malcom

Shirley Malcom opens her address by communicating a sense of urgency: "The policy window for dealing with this issue is open right now and I don't know how much longer it will be open, so we must finish our work." She begins by surfacing her own biases.

Underlying Biases

The Need to Disaggregate "All"

"The generic 'all' does not work for me," Malcom states, "because the generic 'all' does not work for all." Instead, Malcom addresses "all" in a disaggregated way to include two-year and four-year institutions, women, African Americans, Latinos, Native Americans, Asians, Pacific Islanders, persons with disabilities, returning veterans, and women returning to school later in life. In too many cases it is the homogenization of the population that gets us into trouble, she notes. We say "all," but then do no measurement to find out whether the things that are happening are really accruing to all.

There are also "orphan" populations, those currently lacking much data, but there is a need to focus on those populations as well. Persons with disabilities falls into that category and that is not an adequate handle: those with apparent disabilities are not going to experience the same things as those with non-apparent disabilities; those who are deaf or hard of hearing aren't going to relate to the same things as people who are visually impaired or blind or mobility impaired. Another orphan population, Malcom notes, is that of minority women. Although AAAS has worked on these issues since 1975, there is still not enough focus on or attention to this population.

The Underrepresented and Universal Design

"My second bias is that if it doesn't work for underrepresented groups, it doesn't work," Malcom continues, "and that is the majority of the population, that is not a minority." Consider the concept of universal design coming out of the architecture field and the disability community. Is there such a thing as universal design within STEM education? Can we imagine a set of experiences that enable people across that broad spectrum to do well?

Targeting and Mainstreaming

Finally, Malcom adds, we must both mainstream and target. Specific identity-related problems must be addressed, but at the same time if we are talking about "all," we must look at integrating those issues within the overall setting.

Engaging a Tough Audience

The Story of Gigi

Malcom shares a story of from her days as a graduate student as UCLA in the turbulent times of the late 1960s, when she began to wonder whether what she was doing might not be relevant to the rest of the world and was searching for meaning in her own life. When she was asked to take over teaching three biology classes at a Catholic, all girls high school near the campus, she agreed. The principal told her she was getting the "low" students and shouldn't expect a lot from them. The department head would be teaching the high-achieving students.

There was a young woman in one of Malcom's classes named Gigi, who was full of energy. Malcom was aware most of the students were in the class only because it was a graduation requirement, but she was struck by and decided to work with Gigi's enthusiasm. Gigi was an absolute joy, Malcom relates, because everything was a wonderful discovery for her. She worked hard and achieved high scores on Malcom's assessments.

Upon turning in her grades, Malcom was called into the principal who told her, "You know, this is the slowest group, you don't have to give anyone an *A*."

Malcom responded, "I don't *give* an *A*, people have to earn them. And I'm not comparing her against the other students in her class, I'm comparing her with students I taught when I was at UCLA," which effectively shut down the principal's objections.

Gigi got an *A* and the next year was in a chemistry class with another teacher who told Malcom, "She is the best student I have in this class." First, Malcom observes, Gigi didn't have to take the chemistry class and had she not had a good experience in Malcom's class, she probably wouldn't have. Second, the chemistry teacher affirmed Malcom's beliefs about Gigi's capabilities, based on her performance in a class that now included the high-achieving students coming out of the biology course taught by the department head. This experience taught Malcom that the factors outlined here are important when engaging a tough audience.

The Notion of Joy

Malcom learned if she could get students interested in a topic she could make them work harder than they would ever normally work, and while interest is a prerequisite, joy is the ideal. This notion of joy reminded Malcom of a phrase from *The Canterbury Tales*. She went back and looked at work that the English literature academics were doing and discovered that

> "My idea for the transformation of the student experience is basically helping them find joy."
>
> *Shirley Malcom*

What I Learned from Gigi – or Engaging a Tough Audience

- Believing that they can learn
- Expecting them to learn
- Giving them clear messages of the belief and the expectations
- Giving them the tools and resources (strategies, content, ways of thinking)
- Engagement as a requirement
- "Interest" as a prerequisite; "joy" as the ideal

Prologue from *The Canterbury Tales*

"For he would rather have at his bed's head
Some twenty books, all bound in black and red,
Of Aristotle and his philosophy
Than rich robes, fiddle, or gay psaltery.
Yet, and for all he was philosopher,
He had but little gold within his coffer;
But all that he might borrow from a friend
On books and learning he would swiftly spend,
And then he'd pray right busily for the souls
Of those who gave him wherewithal for schools.
Of study took he utmost care and heed.
Not one word spoke he more than was his need;
And that was said in fullest reverence
And short and quick and full of high good sense.
Pregnant of moral virtue was his speech;
And gladly would he learn and gladly teach."

-Geoffrey Chaucer

Access the Original PowerPoint Color Presentation

For full-color renditions of this PowerPoint presentation, go to: nsf-i3.org/conference/

To interpret the graphs in these grayscale renditions, both the demographic code and the bars on the graphs read from left to right.

they surmised that the clerk in *The Canterbury Tales* was essentially a graduate student, and even though the text refers to "philosophy," it was probably natural philosophy. He was hooked into learning and gold and riches were not important to him, what was important was books and the opportunity to explore ideas: "And gladly would he learn and gladly teach."

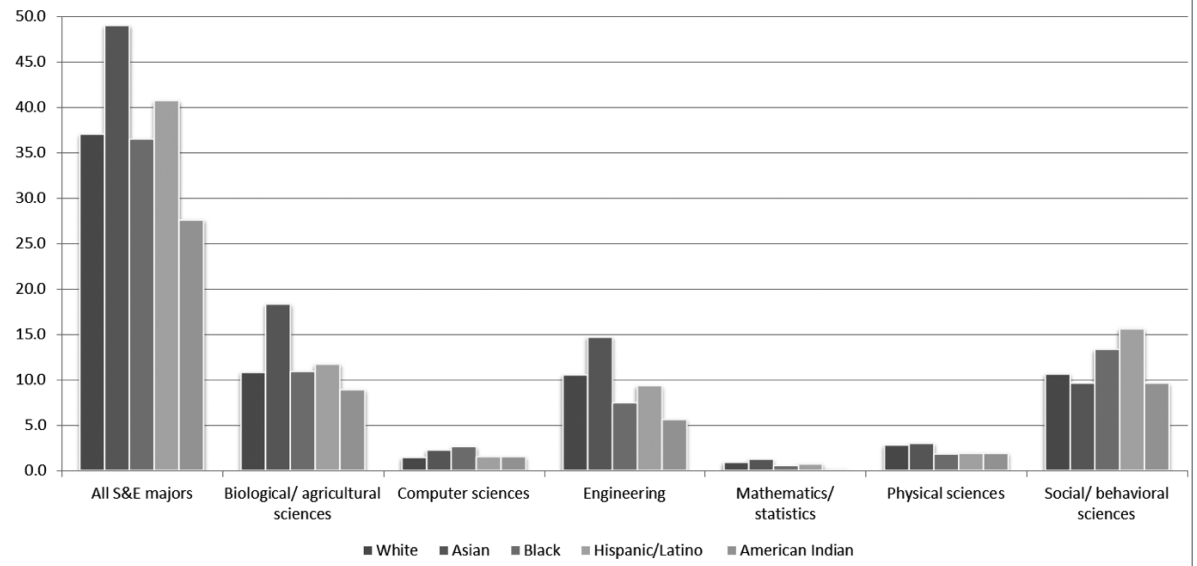
That is where we are, Malcom states. "If we could help our students get to joy, then we wouldn't have to worry about anything else. My idea for the transformation of the student experience is basically helping them find joy."

Initial Student Interest

Freshmen Intentions

In looking at the data, what we find is that there is a lot of student interest in science and engineering going into college as majors, and there are no doubt students pursuing other majors who are also interested in science and engineering. Even those in creative pursuits are probably hooked into STEM in one way or another, given the current pervasiveness of technology. It appears that we are doing well here, independent of group, with the exception of Native Americans, and if we considered health and environmental fields which are not necessarily counted here, that figure might be

Beyond the requirement-
Intentions of freshmen to major in S&E, by race/ethnicity: 2010 (%)



Source: http://www.nsf.gov/statistics/wmpd/2013/pdf/tab2-8.pdf

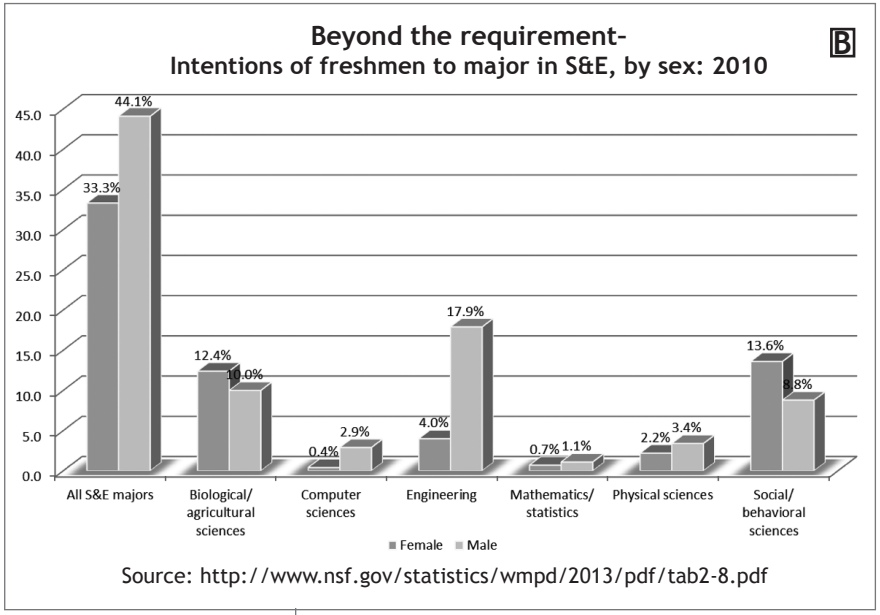
pushed up. Independent of ethnicity we appear to be doing well, especially in the life sciences. There is less interest in computer science, math, and the physical sciences, but there are good reasons for that related to the structure of our high schools, Malcom notes. Those teaching the life sciences are more likely to be educated in the life sciences, while those teaching physics may not be. The point is that there is a lot of interest.

Female Intentions

This relates to females as well (graph B). About a third declare an intention to major in science and engineering. Again we see the biological sciences popping up as a major area of interest for female students, with computer science in the dregs and engineering doing better than computer science, mathematics, or the physical sciences, in spite of the fact that young women are not being exposed to engineering in high school. Some of the things we are doing with young women early on is being effective. The question is how to hold onto that. Malcom notes that the physical science data reflects both chemistry and physics, and the interest in chemistry is much higher than the interest in physics, so that composite number is hiding a lot of what is actually going on.

Tracking Bachelor's Degrees

In looking at the percent change in bachelor's degrees awarded (graph C), you can see in many cases the steady ascendancy of the biological sciences. Malcom suspects that some of the growth in the earth, atmospheric and ocean sciences may be related to interest in sustainability and climate change issues, and we are seeing people starting to follow those interests. Even physics had a bounce, but not much of one, for African American students. As for the results in computer science, "What can I say?" Malcom shrugs.



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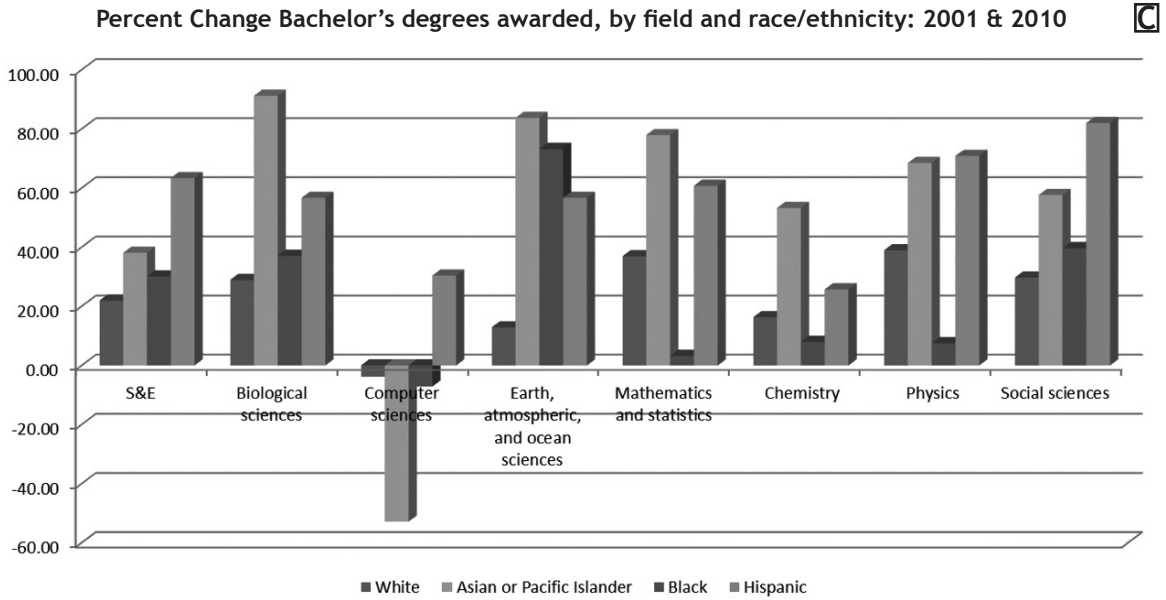
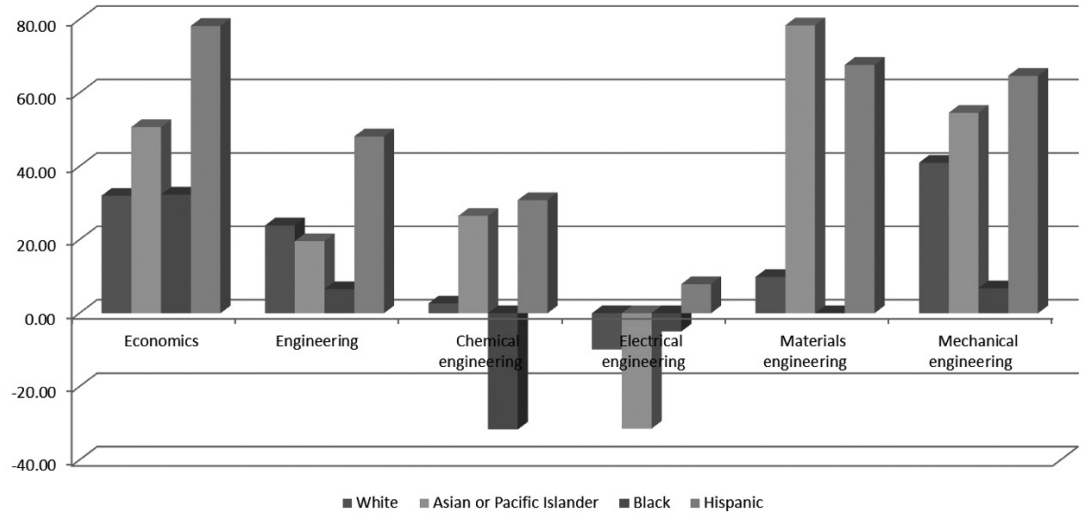


Source: http://www.nsf.gov/statistics/wmpd/2013/pdf/tab5-3.pdf

The next graph (D) includes economics as a separate category because, Malcom observes, economics is more like engineering than other behavioral sciences, and she wanted to see if there had been a bounce specifically in economics. There are declines in some of the engineering areas, especially electrical engineering, but there appears to be steady interest in most of these fields over time.

Percent Change Bachelor's degrees awarded, by field and race/ethnicity: 2001 & 2010 D



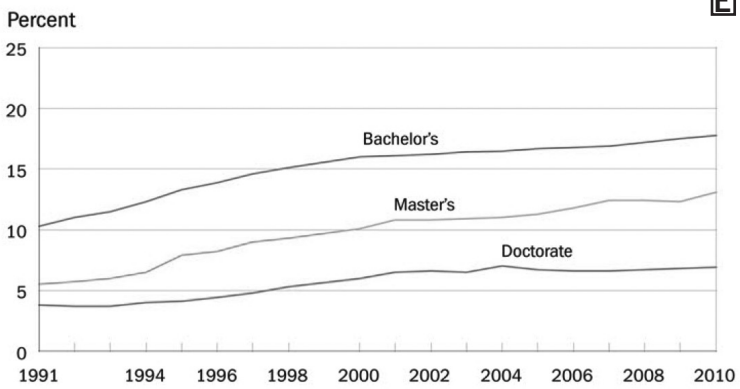
Source: http://www.nsf.gov/statistics/wmpd/2013/pdf/tab5-3.pdf

Degrees Earned by Underrepresented Minorities

In the next graph (E), regarding degrees earned by underrepresented minorities, the lines appear fairly flat and we have a lot of work to do.

Malcom also chose to look at underrepresented minority women (F) for two reasons. Women are a disproportionate share of higher education attendees among minorities, she notes, so when we see these numbers go flat that is not a good sign because their numbers are going up and we are not capturing them into these fields.

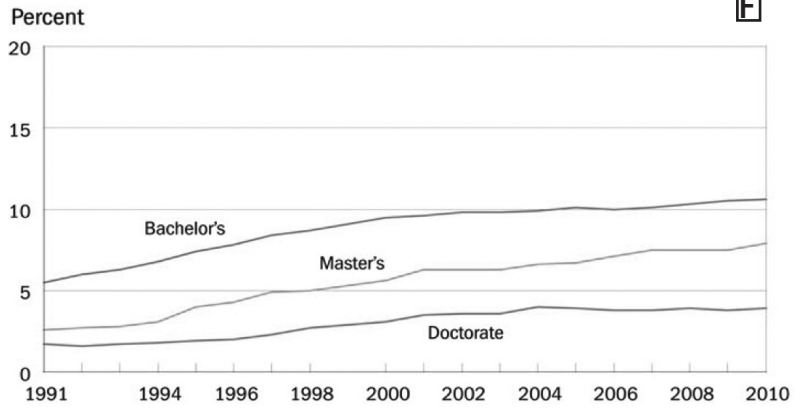
Science and engineering degrees earned by underrepresented minorities: 1991–2010 E



NOTE: Data not available for 1999.

Source: http://www.nsf.gov/statistics/wmpd/2013/digest/theme2_2.cfm

Science and engineering degrees earned by underrepresented minority women: 1991–2010 F



NOTE: Data not available for 1999.

Source: http://www.nsf.gov/statistics/wmpd/2013/digest/theme2_3.cfm

The Non-Transformational

Malcom pauses to review the canon: the course, the credit, and the curve. She encourages conference participants to think about the following as discussions proceed and consider how they constrain efforts at transformation.

One of the things that a course tends to do is lead to compartmentalization, she observes, largely because it is hard in institutions to deal with things that cut across areas. There is a host of issues: Who gets the credit hours? Who teaches it? Who co-teaches it? The amount of time that should be assigned to a course is assumed, as opposed to knowing the amount of time that it takes or imagining the amount of time that someone would spend were they to get really interested.

At a recent international conference Malcom attended, the question of majors came up and one of the attendees said that increasingly you ask students not, "What is your major?" but "What is your question?" As they become interested in these topics it is more fitting that we ask students, "What is your question?" What is it that they are trying to get at?

There are still those who are grading on the curve, and there is a certain culture to the curve, Malcom opines. About fifteen years ago she was at an institution and asked, "What does it mean when you fail half of your students?" The reaction was, "Huh? You mean my job isn't to separate chaff from wheat?" This was an institution with high admission standards, which meant that this was separating wheat from wheat. "Who failed whom in that kind of environment?" Malcom asks.

Another area that should be focused on is bias, implicit and otherwise. While much of the overt is politically incorrect and has fallen by the wayside, the implicit still lingers. Ask a student how they feel when they are an "only," Malcom suggests. "It is not a nice place to live. It isn't even a nice place to visit."

Learning from the Literature

Pursuit of the transformational sends you into many different literatures, which poses a real challenge. There is the learning sciences, the higher education literature, literature on women's studies, African American studies, Latino studies, Native American studies, disability studies, and organizational change studies. This is one of the reasons it is difficult to put your arms around this topic because it requires roaming around in so many different studies, not to mention the discipline-based pedagogies. Malcom reviews a small sampling of the relevant literature to offer an idea of what she is talking about.

The Learning Sciences

Malcom had the opportunity to work with Learning in Informal and Formal Environments (LIFE), a multi-institution NSF Science of Learning Center hosted at the University of Washington in partnership with Stanford and SRI in the early

The Course, the Credit and the Curve

- Compartmentalizing
- Time commitment
- What is your major? What is your question?
- Culture of the curve—separating "wheat from chaff"
- Bias—implicit and otherwise

> "What does it mean when you fail half your students?"
>
> *Shirley Malcom*

Learning from Learning Sciences

- The learner– cognitive-, social- and cultural psychological aspects
- The learning environment
- The instructional practices
- Learning tools
- Experts and novices

Learning from Gender and Race/Ethnic Studies

- The nature of bias
- Reactions to bias-- Stereotype threat
- Gendered and racialized roles, behaviors
- STEM and bias

days of talking about the learning sciences and figuring out what it meant. What it involves is looking at the learner, whether they be cognitive, social, or cultural psychological aspects of the learner. This is not something the individual faculty member is going to look into in an attempt to figure out what kinds of things might be going on with regard to a particular individual that might make it easy or hard for them to learn, Malcom observes.

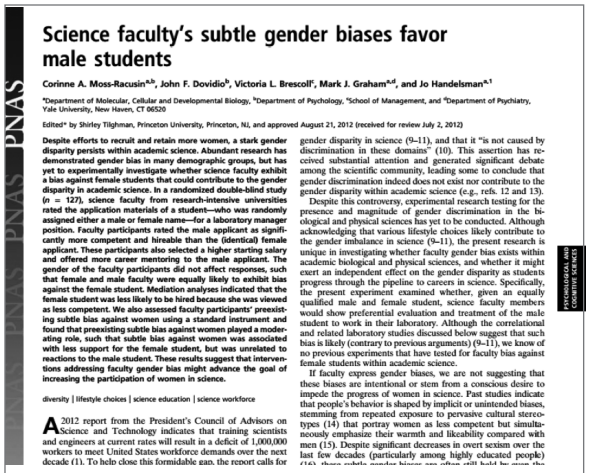
There is also the learning environment and the fact that some spaces actually work better than others in terms of encouraging collaboration and participation and engagement, and that learning environment is not restricted to the spaces within the institution, but extends to the community, the neighborhood, etc. There are the instructional practices: What is it that we do to relate to this learner so that they in fact can overcome whatever barrier they may have to learning a particular topic? And there are learning tools, which may mean anything from a mnemonic to the technology. Then there is the set of work most important to those involved in STEM, which is the way that experts and novices approach problems. These are just some of the important points to consider in the learning sciences, Malcom notes.

Gender and Race/Ethnic Studies

Within gender and race/ethnic studies there is the issue of the nature of bias. For example, Malcom explains, we are beginning to understand that if you have a faculty member who is female, she may in fact get evaluations that are lower than her male colleagues just because she is not what you expect in front of the room as a faculty member. And it is not just bias, it is reactions to bias. What do we do in the face of someone treating us differently or feeling that someone is treating us differently?

Then there is the notion of gendered and racialized roles and behaviors. If one person does something they are considered pushy, whereas if someone else does it, they are considered forceful. It is about ascribing different kinds of thoughts about behaviors and roles that we take, and the expectations for the roles that we take. There are now people looking at STEM and bias and how some of this is operating within the STEM community which, Malcom notes, "is an uncomfortable conversation because we think of ourselves as objective."

More recent work has been done by Jo Handels-



Science faculty's subtle gender biases favor male students

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Edited* by Shirley Tilghman, Princeton University, Princeton, NJ, and approved August 21, 2012 (received for review July 2, 2012)

Despite efforts to recruit and retain more women, a stark gender disparity persists within academic science. Abundant research has demonstrated gender bias in many demographic groups, but has yet to experimentally investigate whether science faculty exhibit a bias against female students that could contribute to the gender disparity in academic science. In a randomized double-blind study (*n* = 127), science faculty from research-intensive universities rated the application materials of a student—who was randomly assigned either a male or female name—for a laboratory manager position. Faculty participants rated the male applicant as significantly more competent and hireable than the (identical) female applicant. These participants also selected a higher starting salary and offered more career mentoring to the male applicant. The gender of the faculty participants did not affect responses, such that female and male faculty were equally likely to exhibit bias against the female student. Mediation analyses indicated that the female student was less likely to be hired because she was viewed as less competent. We also assessed faculty participants' preexisting subtle bias against women using a standard instrument and found that preexisting subtle bias against women played a moderating role, such that subtle bias against women was associated with less support for the female student, but was unrelated to reactions to the female student. These results suggest that interventions addressing faculty gender bias might advance the goal of increasing the participation of women in science.

diversity | lifestyle choices | science education | science workforce

A 2012 report from the President's Council of Advisors on Science and Technology indicates that training scientists and engineers at current rates will result in a deficit of 1,000,000 workers to meet United States workforce demands over the next decade (1). To help close this formidable gap, the report calls for gender disparity in science (9–11), and that it "is not caused by discrimination in these domains" (10). This assertion has received substantial attention and generated significant debate among the scientific community, leading some to conclude that gender discrimination indeed does not exist nor contribute to the gender disparity within academic science (e.g., refs. 12 and 13).

Despite this controversy, experimental research testing for the presence and magnitude of gender discrimination in the biological and physical sciences has yet to be conducted. Although acknowledging that various lifestyle choices likely contribute to the gender imbalance in science (9–11), the present research is unique in investigating whether faculty gender bias exists within academic biological and physical sciences, and whether it might exert an independent effect on the gender disparity as students progress through the pipeline to careers in science. Specifically, the present experiment examined whether, given an equally qualified male and female student, science faculty members would show preferential evaluation and treatment of the male student to work in their laboratory. Although the correlational and related laboratory studies discussed below suggest that such bias is likely (contrary to previous arguments) (9–11), we know of no previous experiments that have tested for faculty bias against female students within academic science.

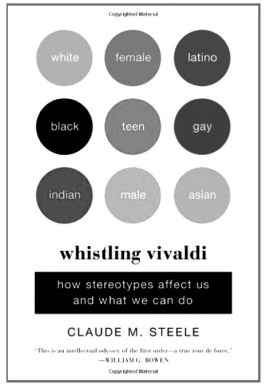
If faculty express gender biases, we are not suggesting that these biases are intentional or stem from a conscious desire to impede the progress of women in science. Past studies indicate that people's behavior is shaped by implicit or unintended biases, stemming from repeated exposure to pervasive cultural stereotypes (14) that portray women as less competent but simultaneously emphasize their warmth and likeability compared with men (15). Despite significant decreases in overt sexism over the last few decades (particularly among highly educated people)

PSYCHOLOGICAL AND COGNITIVE SCIENCES

http://www.pnas.org/content/early/2012/09/14/1211286109

man and others. There is this notion that some of the science faculty, when given the opportunity to make a choice between a male and a female with the same CV but different names, showed bias in favor of the male. They were going to give him more money, thought he had greater potential, and the CVs were otherwise identical. The thing that is discouraging about this, Malcom observes, is that this bias was demonstrated by both the males and the females.

> "...despite the strong sense we have of ourselves as autonomous individuals, evidence consistently shows that contingencies tied to our social identities do make a difference in shaping our lives, from the way we perform in certain situations to the careers and friends we choose."



Malcom recommends the book, *Whistling Vivaldi* by Claude M. Steele regarding how stereotypes affect us and what we can do. The title of the book originates from the story of the author's friend, Brent Staples, who was at the University of Chicago. The university is located in a transitional neighborhood and as a black male walking down the street, Staples would watch people cross over to the other side. He invented his own intervention by walking down the street whistling Vivaldi. He reset those individuals who were on the street with him, Malcom explains, so that they would have to recalibrate who they thought he was.

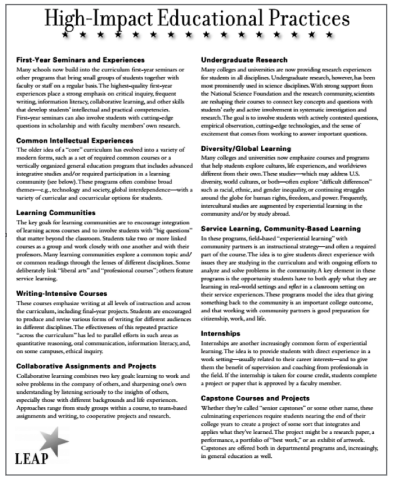
Higher Education Research

In learning from higher education research, we know about these "High-Impact Educational Practices." That extends over into the sciences as well, Malcom notes. Undergraduate research has been identified as a strong, high-impact educational practice, as has study abroad, service learning, and learning communities. A lot of this work has been done by the higher education community and we would do well to remind ourselves that these practices apply in this case as well. "While our provosts may be reading this literature," she observes, "it applies over here with our deans and department chairs in terms of what they may be thinking about."

Where Are the Women?

Malcom returns to the field of computer science, which presents an enigma, and proceeds to dig in a little further (graph G, page 12). The highest participation levels for women in computer science was 1985 and it has been downhill ever since, she reports. How did that happen? There are a lot of reasons that could be given, but she encourages participants to fix in their minds that it is at 18% and falling. Looking into the race/ethnicity subcategories, she notes that the percentages of black and Hispanic males in

Learning from Higher Education Research


High-Impact Educational Practices

First-Year Seminars and Experiences
Many schools now build into the curriculum first-year seminars or other programs that bring small groups of students together with faculty or staff on a regular basis. The highest-quality first-year experiences place a strong emphasis on critical inquiry, frequent writing, information literacy, collaborative learning, and other skills that develop students' intellectual and practical competencies. First-year seminars can also involve students with cutting-edge questions in scholarship and with faculty members' own research.

Common Intellectual Experiences
The older idea of a "core" curriculum has evolved into a variety of modern forms, such as a set of required common courses or a vertically organized general education program that includes advanced integrative studies and/or required participation in a learning community (see below). These programs often combine broad themes—e.g., technology and society, global interdependence—with a variety of curricular and cocurricular options for students.

Learning Communities
The key goals for learning communities are to encourage integration of learning across courses and to involve students with "big questions" that matter beyond the classroom. Students take two or more linked courses as a group and work closely with one another and with their professors. Many learning communities explore a common topic and/or common readings through the lenses of different disciplines. Some deliberately link "liberal arts" and "professional courses"; others feature service learning.

Writing-Intensive Courses
These courses emphasize writing at all levels of instruction and across the curriculum, including final-year projects. Students are encouraged to produce and revise various forms of writing for different audiences in different disciplines. The effectiveness of this repeated practice "across the curriculum" has led to parallel efforts in such areas as quantitative reasoning, oral communication, information literacy, and, on some campuses, ethical inquiry.

Collaborative Assignments and Projects
Collaborative learning combines two key goals: learning to work and solve problems in the company of others, and sharpening one's own understanding by listening seriously to the insights of others, especially those with different backgrounds and life experiences. Approaches range from study groups within a course, to team-based assignments and writing, to cooperative projects and research.

Undergraduate Research
Many colleges and universities are now providing research experiences for students in all disciplines. Undergraduate research, however, has been most prominently used in science disciplines. With strong support from the National Science Foundation and the research community, scientists are reshaping their courses to connect key concepts and questions with students' early and active involvement in systematic investigation and research. The goal is to involve students with actively contested questions, empirical observation, cutting-edge technologies, and the sense of excitement that comes from working to answer important questions.

Diversity/Global Learning
Many colleges and universities now emphasize courses and programs that help students explore cultures, life experiences, and worldviews different from their own. These studies—which may address U.S. diversity, world cultures, or both—often explore "difficult differences" such as racial, ethnic, and gender inequality, or continuing struggles around the globe for human rights, freedom, and power. Frequently, intercultural studies are augmented by experiential learning in the community and/or by study abroad.

Service Learning, Community-Based Learning
In these programs, field-based "experiential learning" with community partners is an instructional strategy—and often a required part of the course. The idea is to give students direct experience with issues they are studying in the curriculum and with ongoing efforts to analyze and solve problems in the community. A key element in these programs is the opportunity students have to both apply what they are learning in real-world settings and reflect in a classroom setting on their service experiences. These programs model the idea that giving something back to the community is an important college outcome, and that working with community partners is good preparation for citizenship, work, and life.

Internships
Internships are another increasingly common form of experiential learning. The idea is to provide students with direct experience in a work setting—usually related to their career interests—and to give them the benefit of supervision and coaching from professionals in the field. If the internship is taken for course credit, students complete a project or paper that is approved by a faculty member.

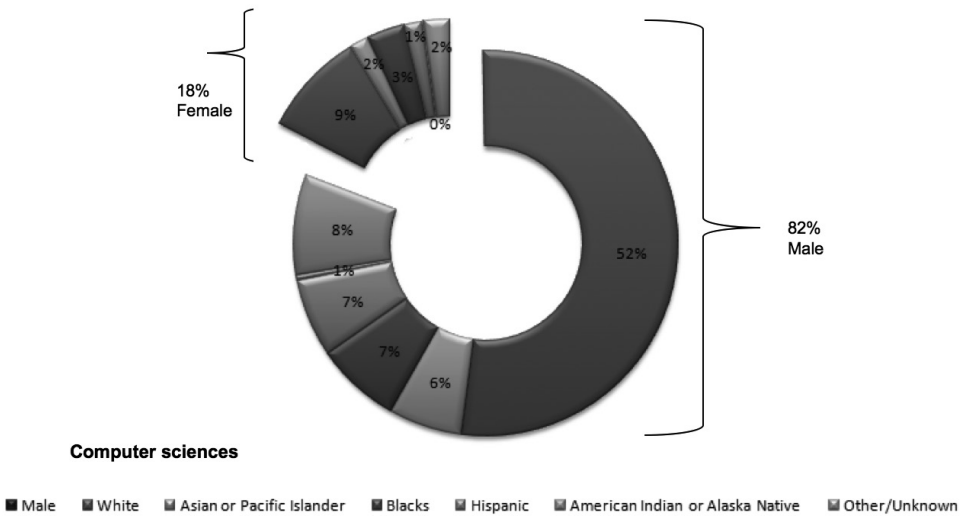
Capstone Courses and Projects
Whether they're called "senior capstones" or some other name, these culminating experiences require students nearing the end of their college years to create a project of some sort that integrates and applies what they've learned. The project might be a research paper, a performance, a portfolio of "best work," or an exhibit of artwork. Capstones are offered both in departmental programs and, increasingly, in general education as well.

LEAP

Source: http://www.aacu.org/leap/documents/hip_tables.pdf

computer sciences is not that bad, which raises another question. How did that get better than in some other areas? Why this area and not math or physics?

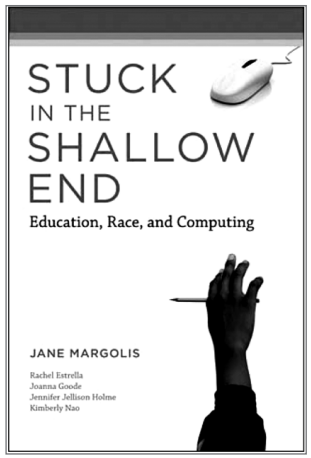
% Bachelor's Degrees, disaggregated by race/ethnicity in "*Low Performance*" Computer Science, 2010

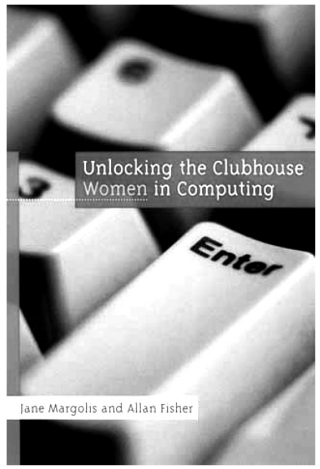


Source: Calculated from NSF, NCES 2010, Table 5.2

Jane Margolis began to help answer some of these questions. She began by addressing the question of where are the women in computer science. *Unlocking the Clubhouse: Women in Computing* is her story about Carnegie Mellon and what they did to turn this around in that institution, from the visible presence of strong women faculty to the change in the way that they looked at admissions. For example, instead of just looking at whether an applicant knows 16 programming languages, they look at whether they can problem solve. When you change the dynamics of the questions that you are asking on the front end, it basically gives you a different set of people on the back end, Malcom observes. "These are the kinds of institutional changes and transformations that we need to start thinking about, but you have to drive from the numbers, from what the situation is in your own institution."

When Margolis conducted her work at Carnegie Mellon, she noted the absence of minorities in the classes and decided to look lower, at what was operating at the high school level, which led to the book, *Stuck in the Shallow End*. Malcom relates that when she read the book in pre-publication, she was viscerally affected.





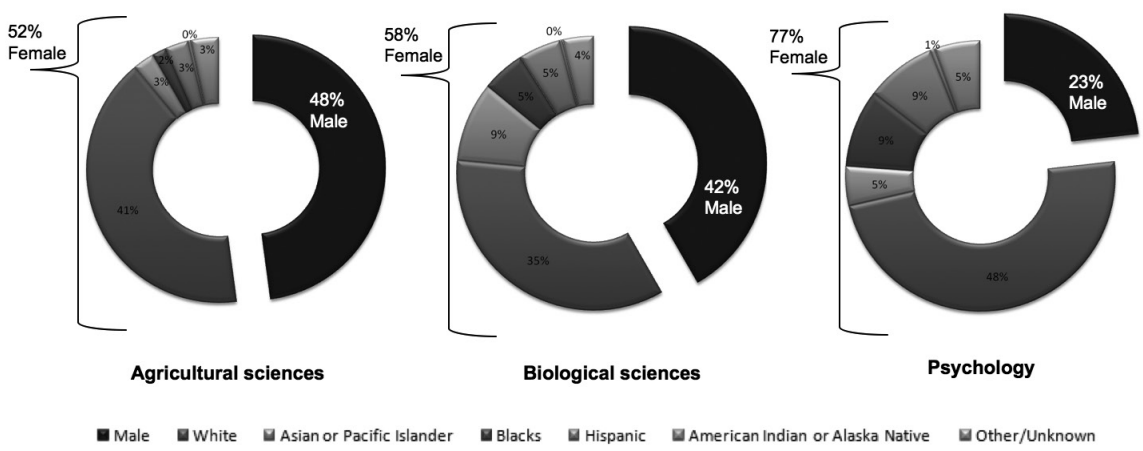
Works by Jane Margolis

"What it did was to show that in policy and practice there was essentially an orchestrated disabling, in a way, of whole populations of students. No access, no opportunities, and those with access were assumed to have more knowledge."

You began to understand, she says, that those numbers didn't get that way because of people's interest. "As I say sometimes, Humpty Dumpty was pushed. The notion of institutional responsibility is a really important one." Malcom looks at fields in which there are big differences in participation and the minority participation numbers are low. An advantage of working at AAAS is that there is a committee that combines women, minorities, and persons with disabilities, allowing them to learn from each other. "I tell the people in the disability or the minority category, let's look and see what happens to the women because in that case we can't say we can't find any. That's not the excuse."

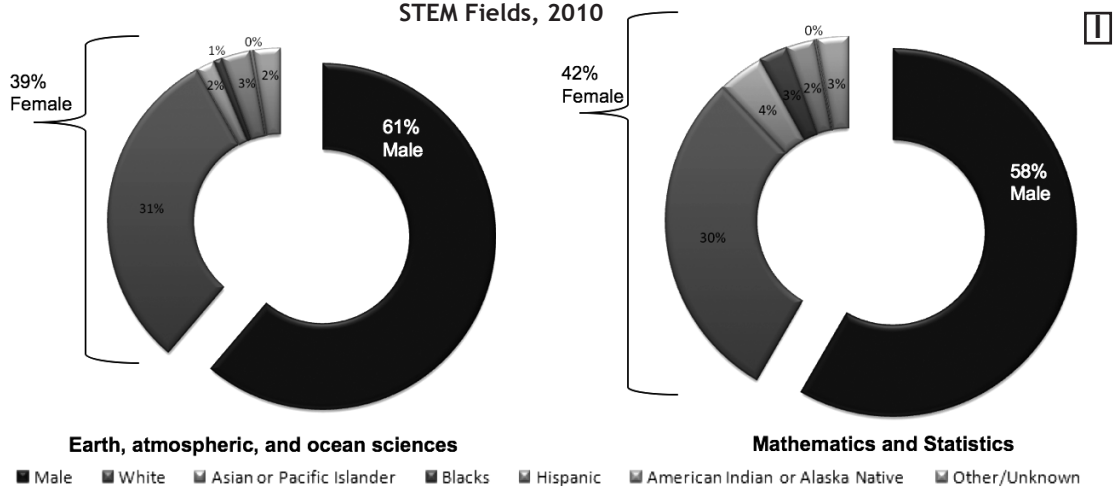
In looking at the women's numbers, they have found (graph H) that there are areas where women are overrepresented, such as psychology, and areas where there is essentially parity, such as the agricultural sciences and the biological sciences writ large. The performance in earth, atmospheric and ocean sciences (graph I) is trending towards parity, a fairly new phenomenon that Malcom believes is driven in part by interest in climate change and important global issues. In math and statistics women have been at near parity for decades, which always surprises people because the excuse for why women aren't at parity in some other areas, such as physics, is that women are not mathematically inclined.

% Women Bachelor's Degrees, disaggregated by race/ethnicity in select "High Performance" STEM Fields, 2010 H



Source: Calculated from NSF, NCES 2010, Table 5.2

% Women Bachelor's Degrees, disaggregated by race/ethnicity in select "Average Performance STEM Fields, 2010 I



Source: Calculated from NSF, NCES 2010, Table 5.2

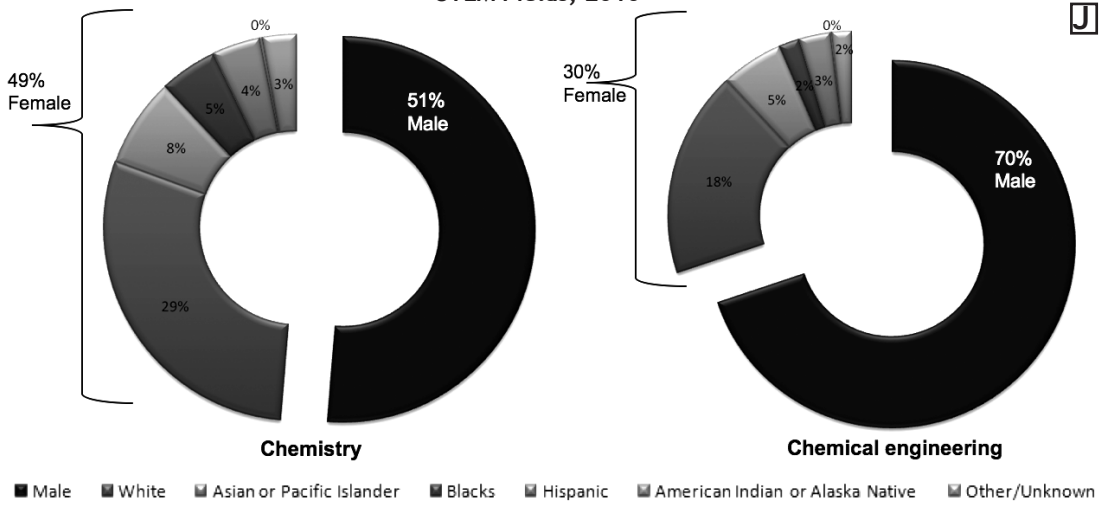
Then there are areas where there is a discrepancy. In chemistry we are at parity; in chemical engineering we are not (graph J). In all likelihood, Malcom observes, this partly relates to where chemical engineers work, and may therefore be a feedback loop from the employment picture. But considering that, the numbers aren't bad, she notes.

Then (graph K) there are the fields of physics, where women have been hovering at around 20% for a long time; electrical engineering, which just seems to get worse; and mechanical engineering, which also just seems to get worse.

"So we do have challenges," Malcom reports, "and we are beginning to focus on those challenges in a very directed way in terms of trying to understand, in a research-based way, what is going on and trying to imagine more thoughtful and powerful interventions that we can put into place."

% Women Bachelor's Degrees, disaggregated by race/ethnicity in select "Average Performance STEM Fields, 2010

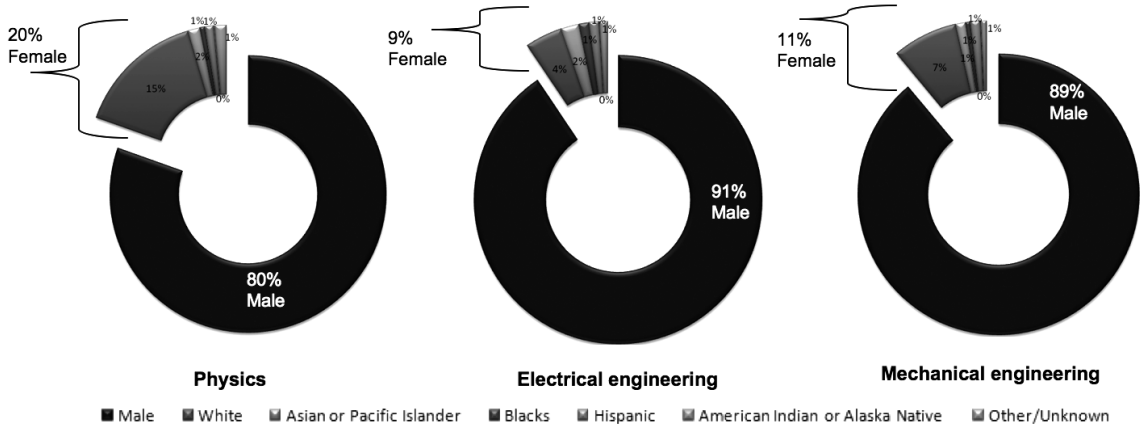
J



Source: Calculated from NSF, NCES 2010, Table 5.2

% Women Bachelor's Degrees, disaggregated by race/ethnicity in select "Low Performance" STEM Fields, 2010

K



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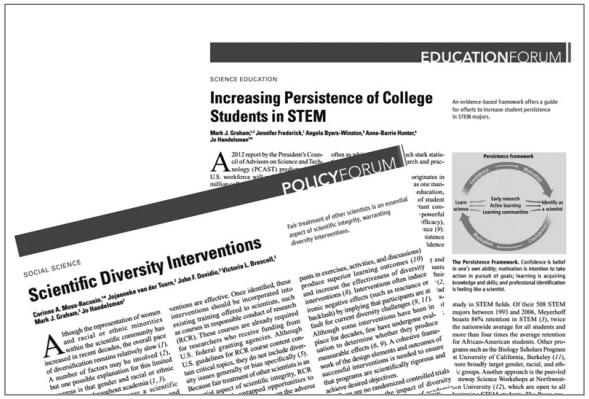


EDUCATIONFORUM

SCIENCE EDUCATION

Increasing Persistence of College Students in STEM

POLICYFORUM

SOCIAL SCIENCE

Scientific Diversity Interventions

Assessment

Measuring What We Value

Malcom then raises the issue of assessment. In so much of our lives, she explains, this question arises. We know who is good and how, and we use proxies for being good.

Note the inclusion of SATs, ACTs, GPAs, SES and zip codes in the list at right. "You can make of those what you will," she states. "Essentially what we have done is to look for proxies that will tell us what is good."

A colleague, Lauren Resnick, once said something that has stuck with Malcom: "We tend to value what we can measure rather than measuring what we value." If we get to the point where we measure things we value, Malcom observes, we will look at things like early research experience and see how students are actually responding to that and how they behave after being in those kinds of settings. "It is like giving a paper and pencil test on football as opposed to seeing how you play. Which one is a better assessment of how you are going to do for my team?"

Then there is the notion of a "blind review." The *PNAS* is, in a way, a blind review she opines, and in a way, we have failed because it was not a blind review. If it were a blind review, how would we do?

We also have lower expectations for many kinds of people, and Steele's work tells us that lowered expectations lead to lowered results. Malcom began to wonder what is happening there physiologically and began reading about things like working memory. Instead of having all of yourself in the game, part of you remains off to one side worrying about how you are going to appear to others. One thing that is interesting in Steele's work is that he says this only happens if you really care about the outcome and are invested in what the outcome is. "This says to me we are doing some really bad stuff to a lot of people," Malcom states.

There are halo effects as well. Asian American women, when reminded they were women, had lowered performance; when reminded that Asian Americans did better, they did better.

"One of the real challenges," Malcom says, "is that this would be fine if it were just an issue to be solved inside of our institutions and we had to just start doing better, but this is not just that. This kind of thinking is undergirding much of the judicial considerations that are going on." She offers the example of "Grutter, Gratz and Fisher," which at bottom says, "Because I did better on this test I am more deserving of admission to highly selective institutions than this person, who may not have done as well on this test." This is assuming that test is a good measure of whatever it is that I say I value, and that is an assumption that we cannot make, Malcom notes. All of this judicial wrangling is related to this issue. It is not benign and we need to take it on as an issue.

Assessment—Measuring What We Value

- SATs, ACTs, GPAs, SES and zip codes
- Early research experience
- "Blind review"
- Lower expectations and halo effects
- "*Grutter, Gratz and Fisher*"

> There is also the notion that we want to find the best students and bring them to us as opposed to a developmental approach in which we want to find the student with the best potential and give them what they need to be stars.
>
> *Shirley Malcom*

Performance and Potential/Promise

- Nature and nurture
- Choosing winners and making winners
- Adding value
- Baccalaureate origin institutions for PhDs

The Playbook and the Game Plan

- What one COULD do vs. what one needs to do
- Gladly would they all learn—professional development of faculty
- Leadership to support development of previously uninvolved faculty, making them unsatisfied with teaching as they were taught—Where they would gladly teach
- Filling the gaps

Performance and Potential/Promise

"There is also the notion that we want to find the best students and bring them to us as opposed to a developmental approach in which we want to find the students with the best potential and give them what they need to be stars," Malcom observes. Students who do really well may have topped out, while there are other students who may have unlimited potential but nobody wants to take a risk, they are afraid to take a risk, or they don't know other ways of looking at the student in order to be able to assess them.

The nature/nurture issue is alive and well, whether we want to admit it or not, Malcom states. We still think there are some students who have it and some who don't. We don't know that we can help people to develop and add enough value. But some of us have seen and recognized how it can be done it differently, she observes. "There is a difference between choosing winners and making winners."

In looking at the baccalaureate origin institutions for PhDs in STEM, she points to a number of resource-starved, historically Black colleges and universities (HBCUs) that don't have anything, and yet people are somehow able to leave there and be successful. Again, she reiterates, this notion of potential and promise is an important one.

The Playbook and the Game Plan

Employing a football metaphor, Malcom observes that the distinction between the playbook and the game plan is the difference between what one could do versus what one needs to do. There are a lot of things we could do, she says, and in many cases institutions have a smorgasbord of things going on, but they don't have a game plan.

With a game plan, assessment is done based on who you are playing, what your issues are, and where you've got to go. It means choosing which of these research-based approaches you are going to use out of all of the things available to you. You look at where you are right now and do your own asset mapping, gap filling, and so on, and try to figure out what makes the most sense.

There is this idea that some things may be important strategically for the game plan, such as the notion of professional development of faculty. This is a hard one, Malcom acknowledges, and it means one has to exercise leadership to support the development of previously uninvolved faculty, making them unsatisfied with teaching as they were taught. "That is really what we have: teaching as you were taught, as opposed to teaching as you were taught to teach, which is something very, very different."

The Educational Value of Diversity

The bottom line is the vision that Justice O'Connor articulated of the educational value of diversity. A few years ago, Joe De Simone

received the AAAS Mentor Award. The first thing he said in receiving the award was, "I can't get value out of my work unless I have diverse teams working on it." The point is that this isn't about equity, Malcom states, it is about getting the greatest value. "You don't have enough juice without diversity in order to be able to produce all the things that we want to produce."

The Educational Value of Diversity

- Joe De Simone's Mentor Award
- Evaluation of STCs– Comparing their engagement of URG students with that of parent departments
- Scott E. Page – *The Difference: How the Power of Diversity Creates Better Groups, Firms, Schools and Societies*
- Finding and building community

A couple of years ago AAAS did an assessment of the science and technology centers, looking at their engagement with underrepresented groups. They were pushing more doctoral students through the system from underrepresented groups than the parent departments of those centers were, Malcom relates, and they were using that diversity to solve those center-related problems in a very focused kind of effort.

"The bottom line on the educational value of diversity is that of finding and building community," Malcom states. "Community can solve a lot of issues for us and right now there is a strong base to make that happen."

Putting the Pieces Together

Malcom reviews the key points, putting the pieces together, and elaborates on the third point, "Understanding the signs and points of loss." She shares something a speaker said to the AAAS committee: "People leave before they leave. They don't just up one day and get out of there. You start to know the signs when they stop taking courses that are required and things like that long before they actually make the changes in the major." One of the things that the PCAST report did was pinpoint introductory courses as being real problems or real opportunities. We need to really look at that, Malcom urges, because it affects not only majors but potential majors as well.

The students, the faculty, and the institution all look at the experience very differently and we need to understand those differences in order to make any kinds of moves.

Regarding shared goals, in many instances we simply don't declare what it is that we want to have happen, Malcom points out. "I told you from the beginning that what I want is joy. I want the passion that we bring for our fields because we fell in love with our fields. I want the joy that the students can have (though they may not fall in love with them enough to major in them) so that they keep returning to them

Putting the Pieces Together

- Drawing on research from many different fields
- Understanding the populations being served in a disaggregated way
- Understanding the signs and points of loss
- The nature of the experience from the perspectives of learners, faculty and institution
- Developing shared goals
- Developing a "game plan" (drawing from a playbook of research based practices)

Putting the Pieces Together

- Filling the gaps (Disaggregate, disaggregate)
- Keeping score (How well are we doing?)
- Making mid-course adjustments
- Supporting collaboration and systemic approaches
- Distinguishing between causes and symptoms
- Responsibility, accountability and leadership

over a lifetime and have access to the ideas and the concepts as they move through their lifetime."

She underscores the importance of developing a game plan, drawing from a playbook of research-based practices. "Let's stop being non-strategic in the way that we think about our work."

Then there is the need to fill in the gaps and disaggregate, disaggregate, disaggregate. We are not going to know how our returning vets are doing, Malcom points out, unless we collect the data in such a way that we can determine if they're having difficulties. We are not going to know if our students with disabilities are having a difficult time unless we collect the data to actually know how they are doing and then look at instructional strategies and practices we can use in order to fill those gaps.

When you have a game plan, an important part is being able to keep score. How are we doing? For whom? In which places? Then there is making mid-course adjustments. How many times, Malcom queries, have you seen cases where football teams who are losing badly go in at halftime and adjust it and end up winning the game? It is necessary to approach this in a dynamic way so that we can make those adjustments that may be needed in order to correct, to adjust whatever is going wrong.

There is also a need to support collaboration and systemic approaches. We have had too many of these one-offs, and instead need to understand that these are extremely complex ecosystems and that the feedback loops that are there are quite strong. For example, what we reward is what we get.

We need to distinguish between causes and symptoms. In many cases we want to go after symptoms and not really go after causes. Or we address the symptoms for some students. That is not sustainable, Malcom explains, because it is often done on soft money.

Finally, there is responsibility, accountability and leadership.

Potential Drivers of Transformation

Potential Drivers of Transformation?

- Shifting demographics?
- Changes in college going populations?
- Shifting pathways in higher education?
- Trans-disciplinarity / interdisciplinarity?
- MOOCs and other technology based experiments?
- Changes in graduate preparation?

What are the potential drivers of transformation? If there are students out there with whom we have not done well, will that compel us to transform, knowing that we could end up going out of business?

Are changes in the college-going population

enough? These are not the 18-year-olds going from home to college, Malcom reminds participants, and it is a matter of understanding what the current college-going population looks like and how it might be different from what we think, the myth of who the college-freshman is.

Are shifting pathways in higher education a driver? We know that there is a lot more use and re-use (in stop and go mode) of the two-year college system.

What about the increasing need for trans-disciplinary and interdisciplinary? The things students increasingly want and the things we want them to think about aren't in that space called "majors," Malcom notes.

What about MOOCs? In talking to some faculty who had been offering some MOOCs, Malcom relates, some said that when they watched themselves they felt they were terrible. Participation in MOOCs is volitional on the part of students, and colleagues are watching, which may drive faculty to recognize they need to up their game and think differently. "I envision MOOCs as faculty professional development," she says.

What about changes in graduate preparation? "We can't keep sending the same players into the game if we're playing a different game," Malcom concludes.

Impediments to Transformation?

You tell me!

Q & A

Gigi and Other Tough Audiences

Q: What happened to Gigi [*page 5*]? Did she go on?

A: I don't know what happened to her, but I do know she was very much reinforced by the work she did in chemistry as well. The young women in that school were from very affluent families and didn't have to go to college, and Gigi chose to go. And if they chose to go, it wasn't because they would ever think they would need the money. That is one of the toughest audiences to really address.

Q: The reason I ask is that I run into so many students like that all the time. One example is a student I ran into at LSU from the wrong zip code. Just graduating from high school was a big thing in her area. Her entire family grew up in one bedroom of her grandmother's home. She came to LSU, got involved in research, and is now a superstar. She graduated last year with a 3.8 GPA and there is absolutely no way that young woman would have done the things she did had she not encountered the right environment and the right teachers. There

Q & A session with Shirley Malcom

Addressing Implicit Bias

Q: What changes can be done in an institution to address implicit bias?

A: What we don't know does hurt us. When we don't realize how much we act that way, then it's okay for us to act that way. I suggest you read those pieces by Jo Handelsman and her colleagues because they begin to talk about the trainings that have been developed around implicit bias. One of the things I think is important to recognize is that we all have biases, but we don't have to be blind about them. I declared mine. In a lot of cases people have biases that they don't know they have, and I don't think fair-minded people want to walk around with those biases. Therefore, people may welcome the opportunity to identify them and to see the blind spots that they have.

I have to believe that, otherwise I wouldn't be in this job this long because, quite frankly, you don't get any joy from banging your head against a brick wall because it feels so good when you stop. That is not my idea of how you do it. You make progress and it means adopting some of those interventions that really put the bias right out there. The *PNAS* article is a good place to start [see page 10]. You can ask people what it is they perceive is going on, which opens the opportunity for a conversation.

are so many stories all of us can tell, and it is refreshing to hear you tell that story about Gigi. There are so many other Gigis.

A: There are a lot of Gigis out there and it is so easy to get lost. I was born and raised in Birmingham, Alabama and attended segregated schools until I left to go to college. When I went to the University of Washington I almost flunked out of chemistry. I convinced one of the TAs, the only African-American graduate student in the department, that I was not dumb, just underprepared. If he had not believed me and helped at that point in time I would not be here today. I think there are a lot of us who are like that, who at some critical point were rescued from the deep end of the pool when we didn't know how to swim.

People have asked me why I didn't ask the professor. I said, "He was white, and I felt he would have looked at me and asked why didn't I change majors." The only African American graduate student in the department believed me when I said that I was not dumb, I was underprepared. I would never have gone to my professor. I learned over time that I could have gone to my professor, but I was a freshman and had just come out of the deep, segregated South. You have students all around you who have different stories, but no less compelling with regard to the identity contingencies that flow from those.

Real-world Application/Assessment

Q: One of the things I've become profoundly aware of recently is how school looks so different from the rest of the world and how what we do in schools doesn't look like what we want people to do outside of schools. I know that's one of the reasons we're here, but I'm interested in your thoughts about that. What do we do to bring alignment to that?

A: In some ways I don't want school to look like the rest of the world. I want you to have a kind of respite from the rest of the world in order to be protected a bit. But venturing into the rest of the world is actually quite good. Service learning, internships, co-ops, things where you are able to apply your knowledge in the rest of the world are very useful because all of a sudden you begin to understand what it is that you really know.

I think in some cases we need to make explicit those things that are implicit, that you don't just get "content knowledge" out of this, but ways of thinking and analytical skills and ways of reflecting on problems that are in front of you. Those are really important, so somehow giving different kinds of assessments may be important, because filling in the bubble is not going to tell you you know how to think. It's going to tell you you know how to memorize, but it's not going to tell you that you know how to think.

Being reassured early on that you know how to think can be quite empowering.

Faculty Professional Development

Q: You talked about making faculty unsatisfied with teaching the way that they were taught. I'm wondering how we do that and how we then give them ways to teach well with the students they actually have as opposed to the students they might think they have.

A: It's the students they wish they had. It is when faculty actually can see student performance, when they have an opportunity to see students whom they taught in another setting doing well. We were in New Orleans for the AAAS meeting a number of years ago. We tend to have what we call Public Science Day, which is an event for kids, for schools, and for the neighborhood prior to the annual meeting. We often build it around a museum or science center, but New Orleans didn't have one, so we had to get together all the different scientific groups and create a kind of science carnival or festival. There was an egg drop and after one of the students successfully dropped an egg and it didn't break a teacher said, "That's surprising because he's one of my *F* students." She was surprised by his success. I think it's a matter of letting the faculty have a deeper look into the student's success.

I met someone by the name of Dean McManus, an oceanography professor at the University of Washington. He said a number of years ago he was thinking about writing a book because he determined that students were leaving his class not really knowing what he thought they should understand, and he felt maybe it was because of the way he had been teaching. He wanted to try something different, and he talked about the fear he had of trying something different. One of the major things he feared was that he wouldn't get the chance to cover all of the material that he needed to get them to understand by the time they left his course if he moved to a more active learning setting. I said to him, "Even if you covered it, it doesn't mean they learned it."

He said, "You're right." I told him he had to give himself permission to try something different. And maybe it's a matter of offering incentives or small amounts of resources to be able to evaluate some of the things that people do want to try. Dean ended up writing a book about the first couple of weeks of that transition entitled, *Leaving the Lectern*. It is about his journey from lecturing his students to active engagement with his students, and about the fear that he had in doing that, that he would be short-changing them. I recommend you look at that because even though it's written from the perspective of oceanography it is much more generally useful, and it's one of those books that can start a conversation.

Spreading the Word Institutionally about High-Impact Practices

Q: You mentioned high-impact practices, saying the people who know about these are the deans or provosts. It struck me because the people in this room are all aware of those high-impact practices because we come to meetings like this and talk about it. How do we move that information up and down the pipeline?

A: I think moving it up is more important first off than moving it down. Why? Because up is where the resources are controlled. Once you start moving the resources to have an affect down, then people will learn about it. There may be an interesting strategy in moving it up, and that is to move it all the way up to trustees and let it come back down. The whole question about trying to manage the resources that it would take to put some of these things in place is, at its core, a fiscal decision. If a group of trustees is engaged with this then the conversation will perforce go to presidents, deans, etc. But the resource issue is key. I say that as a trustee.

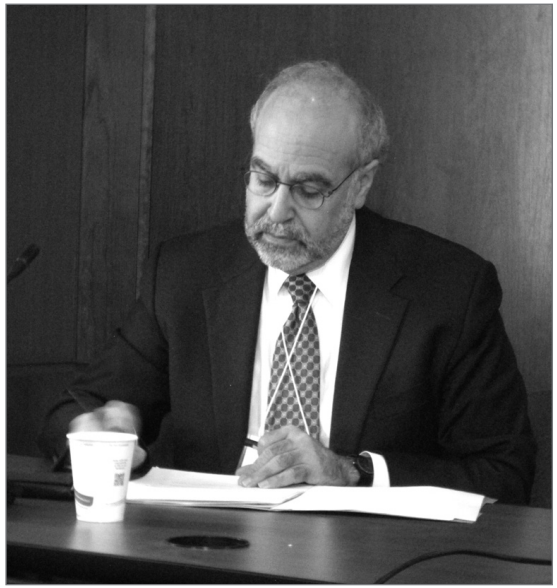
PANEL OF THOUGHT LEADERS

Designing & Evaluating Innovation at Different Scales: from Individual Projects to Structural Reform

Introduction

Initial presentations by this panel of thought leaders highlight key issues, pose fertile questions, and put forth provocative ideas to introduce the breakout sessions they will lead, and to pave the way for later breakout discussions addressing the three major conference themes and the underlying challenge of gathering evidence of effectiveness.

Daniel Goroff



Higher Education Innovation in Context

Daniel L. Goroff
Program Director, Alfred P. Sloan Foundation

Goroff puts innovation in context and talks about the context needed to evaluate innovations. He begins by employing a seafaring metaphor.

Seascape by JMW Turner

In reviewing an exhibit at Oxford of seascape paintings by Turner, the critic Ruskin made the following prediction.

The Critic Ruskin, 1859

"For one thing this century will in after ages be considered to have done in a superb manner, and one thing, I think, only...it will always be said of us, with unabated reverence... They built ships of the line."

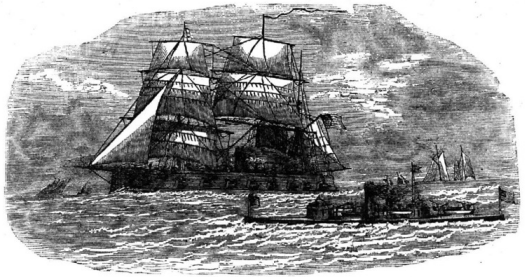
Ruskin was enthralled by these big sailing ships, but as naval historian Morison notes, even as he was writing, the days of the great and noble sailing ships were numbered, which was immediately clear to everyone with the appearance of ironclad gunboats made entirely out of metal and powered entirely by steam, such as the *Merrimak* and the *Monitor* just a few years later during the Civil War.

Ironclad Ships, 1862

"Nevertheless, the next fifty years or so of naval history

was completely filled with turmoil and confusion—just utter nuttiness," Goroff recounts.

50 Years of Naval Confusion



The navy built different ships of all different sizes and purposes and then put metal on them. They trained sailors in how to set rigging and how to capture other ships by boarding them because that's what they always did. They built very odd hybrid vessels that had both steam power and sails, but set all sorts of restrictions and kept track of how much time captains spent under steam because they wanted to make sure everyone was still doing their jobs and rigging the sails.

There were literally thousands and thousands of meetings and boards and reports and they were all set up to conduct studies and formulate all kinds of recommendations. "So this was a time of some risk taking, a time of innovation, there was great pressure on people, and all kinds of ideas about accountability and what we needed to do and how we needed to do it," Goroff explains.

All of this floundering came to an abrupt end soon after a single conceptual breakthrough achieved by Alfred Thayer Mahan. His book was entitled *The Influence of Sea Power on History*. The goal of the modern navy, he wrote, was to command the sea, and this required a balanced fleet consisting of battle ships, cruisers, destroyers, and so on. Nobody had thought about this before, and everyone who was about to be anyone, including Roosevelt and Bismarck, read Mahan and got to work, and the rest is history.

Goroff posits that the current revolution in information technology has put all of us, particularly in higher education, in the same kind of transitional state at the turn of the 21st century that the American navy was in during the 1800s. Some of our high-tech innovations are already beginning to look silly, and it is still up to us to write the book.

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New Book to be called:

"Influence of Computing Power on Higher Education"

"A chapter-by-chapter description would be very premature, but I would like to share some personal observations about how organizations and institutions are changing because of all of these changes around us, particularly with the information revolution," Goroff proposes. He starts by asking what is the problem that each age is trying to solve. While there are lots of new innovations all the time, only some innovations bring about progress, so what is progress?

Alfred Thayer Mahan

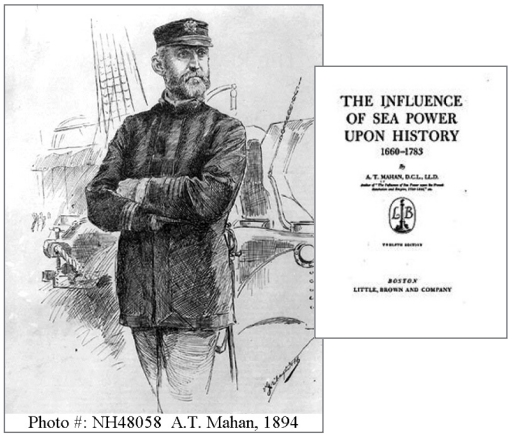

Photo #: NH48058 A.T. Mahan, 1894

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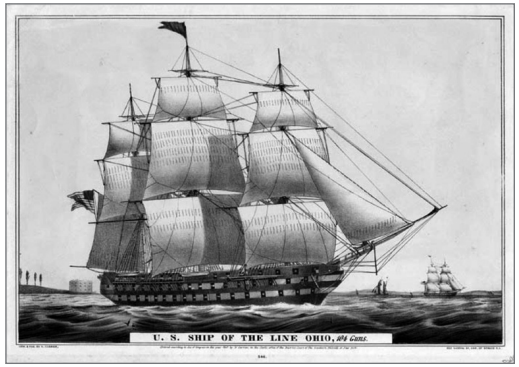
Organizing Metaphors

Age of Trading: Ships



An easy answer is that in every period we are just trying to better our economic lot and live a little more prosperously, which is one view.

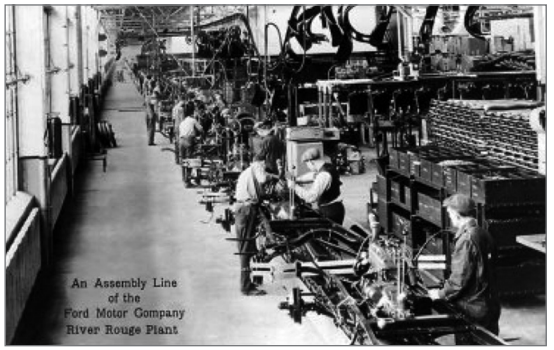
"On a deeper level we can say that each age is distinguished by how it manages to make the whole more than the sum of the parts," Goroff states. "Specifically, how does a society organize people so that they can achieve together much more than what they can achieve individually? I think that is the big question. I will refer to social capital as precisely the ability of groups to function super additively. It is a mathematical term, but it just means that the whole is more than the sum of the parts. And I want to argue that institutions such as educational systems exist not just to create human capital among individuals, but even more importantly that we are the engines of social capital development, which goes to what Shirley Malcom was saying earlier about community."

The organizing metaphor in the Age of Trade were ships, and the success of the magnificent sailing ships depended not only on lots of technological advances, but also on the organization and coordination of teams. The social structure on board these ships was simple enough: the captain told everybody what to do. Education was a simple matter of apprenticeships and learning on the job. Often trades were handed down from father to son, and the ship of the line was, as Ruskin suggested, a great and very well understood symbol of and a template for how the world worked in the Age of Trade.

That period gave way to the Age of Manufacturing, and a perspective that has by now become familiar, which identifies the overarching symbol of business and education in that Age of Manufacturing that we are now leaving as the assembly line.

Organizing Metaphors

Age of Manufacturing: Assembly Line



That has been a powerful organizing metaphor, Goroff observes. To make early car models those captains of industry could begin with semi-skilled workers and could train each to do his or her particular job. Those jobs were broken down into small, repetitive, interchangeable tasks that all needed doing in a timely fashion. Authority flowed down in a pyramid from the few to the many and was not to be challenged by those at the bottom.

"The architects of the American system of public education, such as Horace Mann and Edward Thorndike, were heavily influenced, and explicitly so, by the scientific management theories of Frederick Taylor," Goroff notes. "They spoke

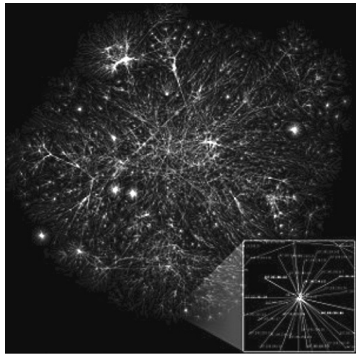
about schools as assembly lines in which masses could be efficiently processed and prepared for life as clock punchers, largely by women with nothing better to do, as long as those women, who were the teachers, followed the orders of a few enlightened curriculum designers."

The system they devised actually served the country quite well, Goroff observes. We had a literate workforce and we prospered as a result. Today the manufacturing model seems pigeonholing and very narrow minded and elitist to most of us.

Today, the overarching symbol that is replacing the tired metaphor of an assembly line is this vision of computer networks and the Web. It is neither centrally controlled nor is it task-specific and nothing goes in a straight line. It is very diverse, and paths are constantly linking and relinking in nonlinear ways.

Organizing Metaphors

Age of Information: Internet



"Although we often speak about organizing ourselves to better bring about technological change, what I am talking about here is how the technological changes are organizing us," Goroff explains. "First ships, and then assembly lines offered templates for how society was coordinated, and now we are turning to the Internet and it is a little confusing."

Goroff draws attention to a few particular trends associated with this change from the Manufacturing Age to this Information Age. "These help explain some of the developments in pre-college schooling and pedagogical practice generally," he observes. "It has become quite fashionable to promote group learning, integrated and multidisciplinary approaches, attention to processes, and customization for learning styles."

What do these trends tell us about colleges and universities? "I would like to claim that there is actually not so much that is new here for us," Goroff asserts. "We may be very enthralled by this, we talk about it all the time, but it is actually not all that new. We have always been knowledge organizations and faculty have always been knowledge workers. It is the companies that are trying to build campuses to look like us. So we shouldn't be trying to look like them, we should know who we are and what we stand for."

Goroff points to a set of distinctions in higher education that relate to why higher education does what it does. "Not just what are we doing, not just with reference to what is going on in the technological world and those innovations, but why we do it. We want to have knowledge, we want to have real communication, to gener-

How Information Age Works

1. From Hierarchical to Flat Organizations
2. From Specialization to Integration
3. From Product Quantity to Process Quality
4. From Mass Production to Mass Customization and Interaction
5. From Competitive Markets to Winner-Take-All Tournaments
6. From Strategic Planning to Agile Development

Why Work on Higher Ed?

1. Knowledge vs. Information
2. Communication vs. Data Exchange
3. Social Capital vs. Human Capital
4. Consensus Building through Argument vs. Persuasion by Advertising
5. Value Added vs. Monetary Profits
6. Long Term Commitments vs. Short Term Trends

Evidence: Context Matters

- Important question isn't: Good or bad?
- But compared to what? Hypotheses!
- Counterfactuals: What would have happened if not for this innovation?
- Just metering treatment group is not enough. Need valid sampling & design.
- Techniques: regression discontinuity, matching, instrumental variables, randomized control trials, natural experiments, etc.

> "We do have to prove our worth these days and if we don't define the criteria then somebody else will."
>
> *Daniel Goroff*

ate social capital and those kinds of long-term commitments. Those are a little different from the way the rest of the world thinks about it."

In talking about evaluation, it is necessary to keep in mind those objectives and goals. "These are not as simple as saying, 'I want to command the sea,' and they're not as simple as saying, 'It's all about my quarterly profit this term.' There are much harder goals, so you have to work really hard to try to evaluate these things," Goroff points out.

Noting that he will delve into how to go about evaluation with participants during the forthcoming breakout session, he offers a brief explanation regarding why context matters. First, it is never a question of whether it is just good or bad. One of the great things about MOOCs, he notes, is that you can do what the rest of the world is doing with A/B testing. You give half of the people who come to your site one page or look, and you randomly give the other half a different page or look, and you see which one works better for you. The next day you give all site visitors the one that worked better. This is happening all the time with commercial sites, Goroff points out, and there is no reason (aside from policy difficulties) we are not utilizing this type of information. "In principle we ought to be able to revolutionize what we do by doing this."

The important thing, he continues, is the context and the comparison. It is never just whether this is a good idea, but compared to what? "You have to have a hypothesis and you have to go out and test it, and this is all about contrafactuals," Goroff explains. "Don't tell me about what happened and how you are going to meter what happened. You really have to think about what would have happened if not for this innovation and make those kinds of comparisons. That takes a lot of planning, it's not always easy, but with the data we have now and the techniques we have now there are all kinds of ways of doing this that are much more effective than they have been in the past. They run the gamut from regression discontinuity to randomized control trials, if you can work that out.

"There are lots of people doing very interesting things you wouldn't have thought possible, and I'm talking about 10 Downing Street, people in the White House, people who are really talking about policy innovations and working out simple ways of doing randomized control trials which are very convincing when you can make them work."

Goroff shares an anecdote from when he took over running the Sloan Research Fellowships, which are prestigious awards for faculty in various fields of science. Part of the charge was to figure out whether they were doing a good job. When Goroff asked about the records for the Sloan Fellowships going back the 30 or 45 years they'd been doing this he was told they had great records with names, affiliations, and so on for all of the winners. When Goroff wanted to see the records for those who didn't win to see if they had done a good job of selection,

the administrator said, "Why would we keep track of them?" You have to have something to compare your results to, some context to put this in, Goroff points out. Sloan is now keeping records of those who didn't win fellowships.

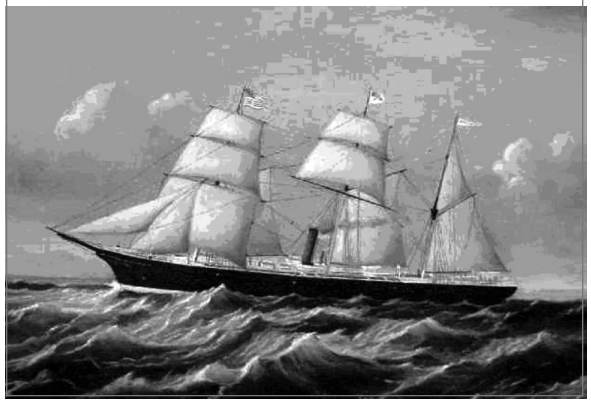
There is also regression discontinuity, Goroff notes, where you had some treatment for some people and you see what happens to them compared to others. "There are interesting things you can do as long as you have that data. We do have to prove our worth these days, and if we don't define the criteria then somebody else will. We have to go about that really carefully and stand up for what we stand for."

Goroff offers a quote by financier Michael Milken who said, "Higher education has low productivity and poor quality control, and therefore I see it as one big takeover opportunity." There are now online and for-profit companies that offer a degree in a box he points out. At a recent conference in Washington, D.C., Goroff heard an Internet CEO declare in a speech, "All of you academics are dinosaurs and you don't even know it. The future is with companies like mine that will be selling information by the bit."

Those words remind Goroff that John Erickson, the inventor of the gunboat the *Monitor*, who predicted in the technological frenzy of the late 1800s that he would soon be producing ironclad ships that were entirely automated and had no need of a crew. "So I am still waiting for this," Goroff states, "and I am also waiting for educational TV to change the world." Instead, he points out, Erickson's technology helped us appreciate what crews are good for that machines cannot replace.

"We must pay attention to what it is about our campuses that does not fit though a wire if we are going to avoid extinction. Do I feel like a dinosaur? No. I feel every day that it is a great privilege to be working with faculty, and it's a lot like being aboard a magnificent ship of the line, but no one should sit complacently in a wooden boat when there are ironclads that are headed up the river ready to blow us out of the water. Rather, like the captains of those hybrid ships of the late 1800s we should both set our sails and proceed full steam ahead."

Set Sails & Full Steam Ahead



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The NAS and Ironclad Ships

An interesting point in relation to Daniel Goroff's talk is that the National Academy of Sciences was formed through an act of Congress under the Lincoln administration in 1863. The first thing that Congress asked us to do at the height of the Civil War was to figure out how compasses work on ironclad ships. We figured that out, and that was also one of the cases where we said, "More research is needed," which is a tradition that has continued for a long time. • Jay Labov

Nancy Shapiro

Perspectives on Institutional Change

Examples of Institutional Change

Nancy Shapiro
Associate Vice Chancellor for Academic Affairs
University System of Maryland

In introducing the topic of systemic change at institutional levels, Nancy Shapiro offers a series of snapshots of what has occurred at the University of Maryland. The University of Maryland has had some interesting opportunities thanks to funding from the National Science Foundation, the Department of Education, and from extraordinary leadership, she observes. Shapiro presents three examples of institutional change around STEM.

Math and Science Partnership (MSP)

The MSP work at the University of Maryland has had a long history, dating back to 2003 and involving a series of projects that have engaged higher education faculty and the institutions with the K-12 schools in the State of Maryland. As a supplement to that MSP work, Shapiro and her team were offered the opportunity to study change and sustainability in higher education writ large. This involved looking at about 40 different MSPs, trying to identify what it is that makes a difference in higher education in implementing some of the MSP work.

MSPs were designed to change higher education simultaneously with K-12 schools. "In some cases that happened and in some cases that didn't happen," Shapiro recounts. Many of the projects had to do with professional development for public school teachers and with faculty engaged in that work. These are some of the learnings from the change and sustainability study:

- Leadership Matters
  There were critical roles for provosts, deans, and department chairs.
- Top-Down and Bottom-Up
  In the successful projects there was the need for bottom-up, top-down influence.
- Engagement of Department Colleagues
  Faculty members engaged in this work had to be able to relate to their departments and bring their department colleagues into the work. If left the work in their own small cubbyhole while they individually developed a relationship with the K-12 school, if they didn't move it into their departments, it didn't result in sustainable change.
- Perceptions of the Core Mission
  While many people thought the link between MSP involvement and their public service outreach was part of their institutional mission, the fact is that most of the administrators at many of these universities didn't see it as part of their core mission. Rather, they saw it as an outreach activity, not a core mission. To change higher education it has to be part of the core mission, Shapiro points out.
- Closing the Loop: Evidence
  The more you use research, the more you use evidence, the more accessible the findings or

the learnings or the transformational opportunities happen in higher education and K-12. Evidence, accountability, and as Daniel Goroff said, understanding the context of those observations, really matter.

- New Structures, Boundary-Spanning Roles
  Investing in new, boundary-spanning structures on campus was transformational. For example, learning assistants, where the department or the dean offered a sustainable opportunity for undergraduates to mentor other students was transformational. Or the role of administrative faculty, those paid partly as faculty, but who also became administrators such as faculty fellows, or who conducted professional development within their departments. That is a bridge-spanning, boundary-spanning opportunity, Shapiro points out. Or new centers, whether a STEM center or multidisciplinary center, that serves as the go-to place for opportunities to work with the schools or with the department.

Part of what was learned in this study of change and sustainability in the MSPs is that you needed all of these things to be happening if any of this change was going to take root in higher education.

STEM Migration Study

Shapiro and her team were hired at the behest of the Business Higher Education Forum due to the low participation and graduation rates in computer sciences. In Maryland there are 16,000 jobs that are vacant because they need a cybersecurity workforce, which comes down to computer science and mathematics. A pipeline was needed, and the business community was very interested in figuring out what was going on with computer science. As a result, Shapiro and her team did a STEM migration study looking at a comparison of computer science attrition and retention compared to mathematics and engineering, and then taking those three disciplines and comparing them to retention in business. "Again, context," Shapiro notes. "What are you comparing STEM migration to?"

Business schools have limited enrollment programs, requiring people to pass a certain threshold of competence for entry. It requires a certain threshold of knowledge and ability to get into computer and science majors. What happens to them? Almost 90% of the business majors graduated in business. In computer science, engineering, and math results were interesting. This study will be published but highlights are offered here. Focus groups are exploring some of the questions that have arisen. For example: Why do women who leave engineering persist in their education while the men who leave engineering drop out?

"Computer science has some work to do," Shapiro observes, "and we have reason to believe that we can do some work on that, but what we are looking at is: How do you create a body of evidence that you can present to an institution to start making change and start having a disciplined look at itself?"

Highlights: STEM Migration Study

- Engineering majors had the highest retention rate, mathematics was second and computer science was third.
- Women who were in engineering and dropped out after the first or second year ended up persisting and graduating at the same rate that the business majors graduated.
- Many of the men who dropped out of engineering stopped and dropped out of school.
- Many of those who dropped out of math went into teaching as opposed to another field.
- Those who dropped out of computer science went into another science, math, or something else.

> How do you create a body of evidence that you can present to an institution to start making change and start having a disciplined look at itself?
>
> *Nancy Shapiro*

Course Redesign Work

In course redesign work, Shapiro explains, "We want to cast the net large. You don't know which of the students in a first-level biology class or chemistry class or math class may end up being a STEM major. Why should we toss everybody into the same pool without some kind of analysis of where we are missing the boat? We wanted to change the way we were teaching these courses so we could engage students more directly in learning."

The work was based on Carol Twigg's course redesign model, which involves an analysis of what the biggest problems are on campus, the courses with the largest dropout rates. With any tweaking done to that course you can see progress, Shapiro explains, because with a lot of numbers you can see more progress. Redesign includes regularly monitoring student progress, offering assistance in different ways, using technology in different ways, and freeing up faculty members. That may involve using undergraduate learning assistants for one hour while faculty members do something else so that the time is spent in a different way.

The course redesign work was done in teams and had bottom-line requirements for participation, including insistence upon institutional grants. Individual faculty interested in participating were required to get approval from department heads. These were courses that had multiple sections and there was worry about course drift, Shapiro explains. You are teaching 13 sections of Math 100 and every faculty member and TA is teaching it a different way. To make sure that everyone was teaching in the same way there were lots of meetings and collaboration, and there were common exams. Everyone had to agree to these parameters.

Controlled studies were conducted to look back at what the dropout rates were before the course redesign, after the pilot, and after the full implementation. "So we had evidence," Shapiro relates. "We didn't just take the evidence to the department chair, we didn't just take it to the dean, we actually presented it to the board of regents. The board of regents has the responsibility to spend public money well. We have a STEM deficit in our state, the business community is going crazy because we don't have enough cybersecurity people and our governor wants to be known for cybersecurity.

"There was pressure on the board of regents to solve these problems and we provided some evidence that we could solve those problems by working on a number of transformational approaches. As a consequence, in our system strategic plan for the next five years, one of four major themes was 'Transforming the academic model to meet the higher education and leadership needs of Maryland's 21st century students, citizens, and business.' As a consequence, the board of regents invested in something M.J. Bishop will now tell you about."

Systemwide Transformation

M.J. Bishop

Director, Center for Innovation and Excellence in Learning and Teaching, University System of Maryland

Venn Diagram of Sustainability

M.J. Bishop explains that she was hired in June to direct the Center for Innovation and Excellence in Learning and Teaching. "The job description was largely focused on faculty development because at that point in the system's thinking, we needed to fix the faculty. They needed to understand more about pedagogy, they needed to understand more about the things that make a difference in the way people learn."

In the nine months since she has been in the position, there have been pockets of this work cropping up across the system. Across most of the institutions there is someone in a position similar to Bishop's, generally at the provost assistant or associate provost level, who is now in charge of helping to facilitate academic transformation at their institutions. "Given that, what does my job at the system level need to look like?" Bishop asks.

As the mission evolves, it has become clear that it needs to be more about sustainability. Most sustainability models have a Venn diagram with three circles. At the top is generally the economic piece. This is a piece where in higher education and certainly at the system level, the focus is on the notion of increased learning at a lower cost, learning productivity, and how we make that happen, Bishop relates. Course redesign was a systemwide effort towards trying to address that.

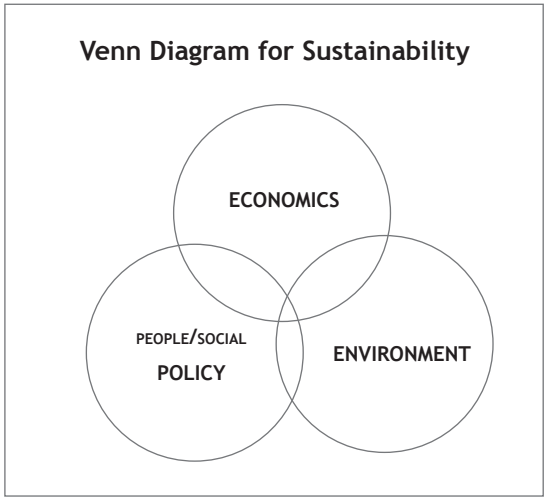
The two other circles are of great interest to Bishop. On the one side is the environmental piece. What does the environment look like and how does that affect the learner's experience? When Bishop first started in her position she did a tour of the institutions, and at one of the universities she was grabbed by a faculty fellow, "one of the rock stars in course redesign in the system." She guided Bishop into a dilapidated classroom arranged theater-style with tiny desks and said, "This is where I teach my redesign course. What are you going to do about it?"

"It dawned on me that this is about academic transformation," Bishop says. "It has got to also be about the environment. You looked into the eyes of this woman who has been a rock star in course redesign and she is beginning to get burned out. She is losing motivation because of the seeming lack of support for the work that she is trying to do to move things forward."

The last circle in the Venn diagram is typically depicted as people or social, or, Bishop argues, policy. This has to do with the sort of things that are impeding academic transformation, just based on the policies of a system or institution.

Tapping Expertise; Potential Obstacles

Bishop then offers an example of the type of thing she and Shapiro will tackle during their



M.J. Bishop

breakout group and relates that example to the presentations heard thus far. While Shirley Malcom noted that there is a body of knowledge that needs to be understood that crosses multiple literatures, Bishop argues that there are people who do understand and have studied this cross-section of literature, many of whom are on conference participants' campuses in the colleges of education. Bishop encourages participants to tap that expertise and try to see whether or not there are people in those colleges of education who might be able to help.

Bishop then asks participants: What would you guess their response would be if asked for help? Participant comments include: "limited resources," "not my job." Bishop notes that another objection might be that those being approached in the education departments have promotion and tenure policies that prohibit them from using their time for these kinds of service activities. "These are the sorts of procedural and policy factors in higher education that prevent that kind of collaboration from occurring as it needs to in order to raise all boats," she observes. The goal during the breakout session is to come up with a comprehensive list of those sorts of things.

Tools for Steering the Course

Daniel Goroff mentioned Mahan's book, which revolutionized thinking about how we use the navy. "I can think of several analogous works, though some of them are a little dated," Bishop observes. "I'm thinking of Gagne's *Conditions of Learning* and Bloom's *Taxonomy of Educational Objectives*. These are those sort of systematic looks at the ways we might think about using our technologies to help really make a difference in education, particularly when we think about technology in a really broad sense. Not the devices but rather our use of tools and systems in order to address a need that currently exists. I'd encourage us to think about those things as we move forward."

Learning Spaces

Jeanne L. Narum

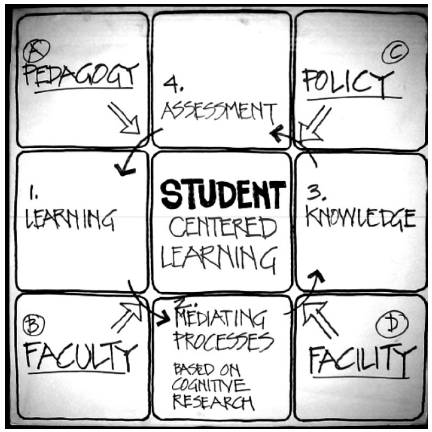
Principal, Learning Spaces Collaboratory;
Director Emeritus, Project Kaleidoscope;
Director of the Independent Colleges Office

Jeanne Narum refers to Daniel Goroff's statement that we should be explicit about who we are and what we stand for. "I think that physical spaces are one way, when students walk onto campus, that they see how learning happens on that campus." She recalls a thought from Goroff's writing that influenced her early on during her work on Project Kaleidoscope, the idea that we could teach them in rows when they were going to work in rows.

To think creatively and productively about space, you have to explore learning and space from as mnay angles, and with as many "design languages," as possible, Jeanne illustrates the process with several stories regarding her work.

Thinking Visually and Metaphorically

Doing workshops on planning learning spaces involves trying to imagine things, getting it out of participants' heads and using different ways



of thinking about the space rather than just words. The visual below is from a session at Cranbrook in Michigan where, after a morning spent talking, groups went out to generate visual metaphors for planning learning spaces, and this was one of them.

"Why I am starting with this is because this is how your innovation projects happen on campus. The learner is at the center and all of these other things feed into the discussion. But unless it is learner-centered planning, we aren't going to get the right kind of space. What happens on many campuses is that the facilities people think that they run the planning of the learning spaces."

At right is another metaphor from the Cranbrook workshop, depicting the undergraduate learning experience as a bridge, preparing students for their future. These drawings are an attempt to get people to think in a different way about shaping a learning environment.

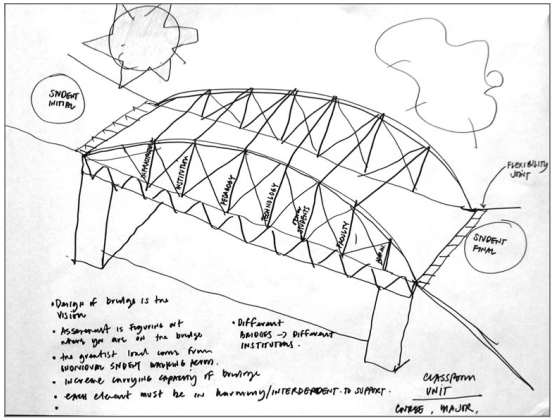
Jeanne also emphasizes the importance of Shirley Malcom's point that intentionally involving a diversity of people informs and strengthens what you do, what you can imagine. Twenty years ago when Jeanne began this work, she notes, there was not the body of research about how space matters to learning. A lot has been learned.

Space to Support Communities for Learning

Nancy Andreasen, in *The Creating Brain,* talks about the kind of community and environment that sparks and nurtures creativity: mentors, funding, people stealing ideas from each other,

The Creating Brain by Nancy Andreasen

Jeanne Narum



cutting edge learning environments. Another useful work that is "unmissable if you are going to transform the learning environment" is *Facilitating Interdisciplinary Research*. "We are at the point of getting it right," Narum observes, "so conversations like this here and on your own campus are important."

What Do You Want Your Students to Become?

Narum received a grant from the National Science Foundation to prepare a guide for planning for assessing learning spaces. Upon receiving the NSF grant she and her team spent a whole weekend searching out a path for their work, coming up with this first, focusing question: What do we want our learners to become? This question leads to answers that are of a quite different kind from those most often heard, such as, "We want them to be critical thinkers" or "good communicators," or "able to work in collaborative teams." Narum's team then spent six months working with 16 or 17 institutions to address this question. These institutions found that they had a difficult time pushing the envelope and thinking about what they wanted their students to become.

"We weren't even talking about spaces until they got that first part right," Narum relates, "and *then* they talked about what the students would be doing, the learning experience, and then what spaces enable that experience." (Her breakout session later in this meeting will flip this discussion to focus on a further challenge growing out of this foundational one: What do participants want their institutions to be recognized for becoming?)

The First Year Experience

The PCAST report offers a major recommendation found nowhere else but in that report: Pay attention to the first-year experience of the undergraduate students. The breakout session will involve drawing a picture of a space that prospective students

What Do We Want Our Learners to Become?

WHAT DO WE WANT OUR LEARNERS TO *BECOME*?

- Agents of their own learning.
- Integrative thinkers and problem solvers.
- Empowered communicators and leaders.
- Model-based reasoners.
- Resilient experimenters.

WHAT EXPERIENCES MAKE THAT *BECOMING* HAPPEN?

- Tackling ill-structured, open-ended complex problems with others.
- Searching for, finding, and sharing relevant, reliable, and up-to-date data with team members.
- Blending disciplinary concepts, methods, representations toward solving problems.
- Creating, sharing, debating, and defending models (graphical, diagrammatic, mathematical).
- Trying, failing, and recovering.

WHAT SPACES ENABLE THOSE EXPERIENCES?

- Authorable, responsive, flexible spaces.
- Spaces that invite the articulation and representation of provisional ideas and hypotheses.
- Spaces that support changing, responsive, collective leadership.
- Spaces that support rebounding from impasses and failure.

Problem-Driven Learning Spaces

Georgia Institute of Technology

WHAT DO WE WANT OUR INSTITUTION TO BE RECOGNIZED FOR BEING, FOR BECOMING BY PROSPECTIVE STUDENTS AND THEIR FAMILIES?

WHAT INSTITUTIONAL POLICIES, PRACTICES AND PROGRAMMING WILL MAKE THAT HAPPEN?

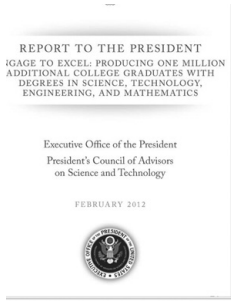
WHAT KIND OF SPACES WILL SIGNAL THAT VISION TO POTENTIAL STUDENTS AND THEIR FAMILIES, ILLUSTRATING OUR GOAL TO STRENGTHEN STEM LEARNING FOR ALL STUDENTS FROM THE VERY FIRST DAY?

PCAST: Engage to Excel

The first two years of college are the most critical to the retention and recruitment of STEM majors. These two years are also a shared feature of all types of 2- and 4-year colleges and universities—community colleges, comprehensive universities, liberal arts colleges, research universities, and minority-serving institutions.

In addition, STEM courses during the first two years of college have an enormous effect on the knowledge, skills, and attitudes of future K-12 teachers.

For these reasons, this report focuses on actions that will influence the quality of STEM education in the first two years of college.

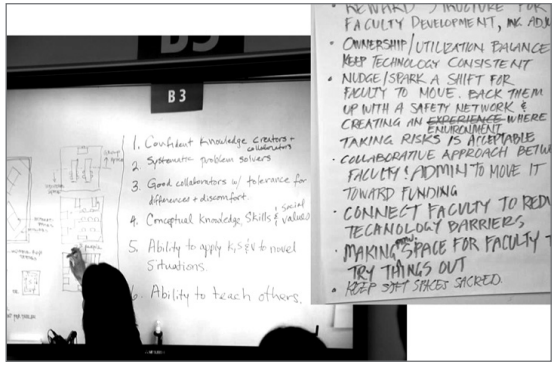

REPORT TO THE PRESIDENT
ENGAGE TO EXCEL: PRODUCING ONE MILLION ADDITIONAL COLLEGE GRADUATES WITH DEGREES IN SCIENCE, TECHNOLOGY, ENGINEERING, AND MATHEMATICS
Executive Office of the President
President's Council of Advisors on Science and Technology
FEBRUARY 2012

To Download the LSC Guide:

The LSC Guide: Planning for Assessing 21st Century Spaces for 21st Century Learners
Learning Spaces Collaboratory
http://www.pkallsc.org/basic-page/lsc-guide-planning-assessing-21st-century-spaces-21st-century-learners

and their families can walk into and say, "I know what this institution is about." The PCAST report, Narum notes, is one of the better reports out that is very specific, identifying how change should happen, the nature of change, and the fact that people haven't paid attention to change. It is a work that should be on the desk of everyone continuing to work on innovation and change.

The photo below shows the kind of work that will occur during the breakout session, first identifying what participants want their learners to become and then features of the spaces and of the policies and practices. For example, there may be a collaborative approach between faculty and administrations to move towards funding. There is a disconnect between why we want to change the spaces and getting the money to



change the space.

Everyone at the University Learns in Space

To convey how diverse this inquiry into learning spaces can be, Jeanne recounted stories from several universities:

Two weeks ago Narum conducted a workshop in San Antonio for presidents and chief facilities officers. By the end of the workshop each of the participants had to have an audacious take-home question to bring back to their community.

- What is the biggest (most audacious) question we need to be asking in shaping and redoing 21st century STEM learning spaces for 21st century learners?
- What lessons can we share about how to identify and address such questions in the process of planning?

How does the changing context influence our shaping of 21st century STEM learning, learning experiences, and learning spaces?

At-the-table discussions and reporting out.

LSC/AI 2014

For example, "Does this space spark the desire for learning in every type of student and faculty?" This question came from one of the presidents, and he was going to bring this question back to his planning team.

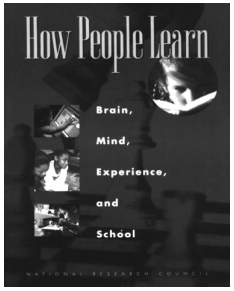
Narum moves on to Purdue University and their Discovery Learning Research Center. The workers in this center are students. The faculty come here and are assessed, advised

From LSC Guide: Discovery Learning Research Center—Purdue University

How learning happens (1999 & 2011)

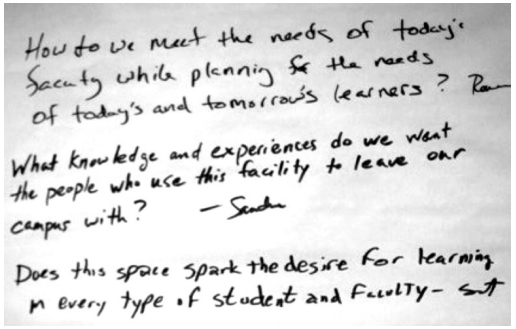
Learning:

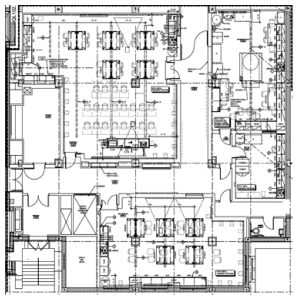
- builds on existing knowledge
- requires active cognitive challenges
- is structured
- occurs in context
- is reflective
- is social.



How People Learn: Brain, Mind, Experience, and School, National Research Council. Washington, D.C.: National Academy Press, 2000.

Audacious "take-home" questions





- Grouping like labs in a single area
- Gives the majors a sense of ownership
- Gains synergy between courses

LSC Archives - West Point

From the LSC Archives: Maker Space —University of Michigan Library (found/repurposed space) LSC Webinar 10/13

They can learn to translate challenges into opportunities.... (Council on Competitiveness)

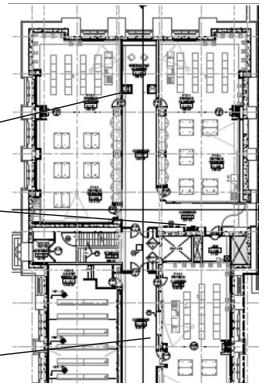
and nurtured. Narum points to the feature of a walkable grid above a meeting space allowing them to change the lighting and other elements.

Next is a "classatory" at West Point. When they were going to remodel a space, they wanted to blur the distinction between class and lab and came up with the title of "classatory," allowing you to go back and forth seamlessly. You can see what they did and why they did it in the photo.

The Maker Space at the University of Michigan is a campus-wide initiative for multilearning

Comfortable Building

- Why should the building look like a prison?
- Soft seating at the end of halls
- Make science visible items in "dead space"
- Adding "bumper spaces"



LSC Archives - West Point

teaching courses with specific outcomes at the university level. They are giving small grants to faculty teaching team-taught courses. This is a room taken over in the library.

Institution-wide, the criteria or measurement involves using multiple perspectives in addressing problems or issues, connections between major concepts and various fields of study, and identifying the components of a problem or issue. They have a set of institution-wide measures against which students in the courses were being measured by the Center for Teaching and Learning at Michigan.

At Vision and Change, Narum had a poster on spaces, and when a young, first-year faculty member from Georgia State University came up and said he had been given a space and a little bit of money, $80,000, and didn't know what to do with it. Narum called an architect friend in Atlanta and urged the architect to help. Below is what he arrived at.

Narum refers participants to Carl Wieman's paper as another resource for planning spaces.

Collaborative Learning Lab for my new theme-based laboratory course, bioinformatics and cell biology. I sought to develop a hybrid computational/molecular laboratory for students that fosters team research. The computer lab is flanked by 2 ~200fr^2 molecular biology labs in which students will validate their analyses.

Georgia State University – Vision and Change

Think about a space in which students can practice becoming scientists, she urges.

Carl Wieman. "Applying New Research to Improve Science Education."

Issues in Science and Technology. Volume XXIX Number 1. Fall 2012.

- ...the value of the educational experiences should be measured by their effectiveness at changing the thinking of the learner to be more like that of an expert when solving problems and making decisions relevant to the discipline...
- Specific elements, collectively called "deliberate practice,: have been identified as key to acquiring expertise across many different areas of human endeavor....
- ...those cognitive processes that are explicitly and strenuously practiced are those that are learned...

In the photo, there are old and new spaces at the University of Maryland, Baltimore County, where they not retainng students in STEM fields. As one faculty member asked to design a course there noted, in the original space the students could not understand what it was to become a chemist.

Traditional lecture hall before the Discovery Learning Center at the University of Maryland, Baltimore County

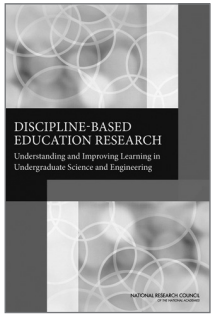
From the LSC Guide: Discovery Learning Center University of Maryland, Baltimore County

At the University of Minnesota, the picture shows where they started. The idea, Narum says, is to start small and experiment. "Planning spaces is one of the more unique opportunities to play around and wing it. Changing faculty is harder than changes spaces," she observes.

Narum then references a series of reports that together have deeply influenced her thinking about learning spaces. Each of these reports suggests questions that should be asked in the planning of learning spaces, Narum notes, and they all relate to the kinds of spaces you should have.

Discipline-based Education Research (DBER)

- Problem-solving may be the quintessential expression of human thinking.
- Society's most important problems are usually ill-defined in some way.



From the LSC Guide: Active Learning Classroom University of Minnesota

From the LSC Guide: Active Learning Classroom University of Minnesota

Access Free NRC Reports

All of the reports that Jeanne mentioned except for one are from the National Research Council and you can download any of those reports for free if you go to the National Academies Press at http://nap.edu/ and use their search engine to find the title you are interested in. • Jay Labov

First about learning: *How People Learn* is an important, research-based account of learning and how it is facilitate - by teachers, by curriculum, by activity-design. The NRC report *Discipline-based Education Research,* discusses problem-based learning in a unique way. Taking this further, *A New Biology for the 21st Century* has implications for space planning and putting faculty in different places together for adjacencies between departments. When using this in workshops, Narum asks what is missing and points out, "It is the student who can fix the problem. The puzzle has to be fixed by the student."

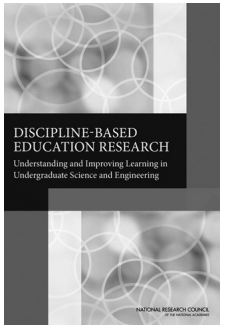
Another critical report is *Expanding Underrepresented Minority Participation*. Narum observes, "We aren't going to get anywhere in this country unless we start with this at the heart of the portfolio of things we are addressing."

Engineer of 2020 says what the 21st century student should become in a way that none of the other reports do. While the others talk about teaching and learning, this talks about the student.

Narum leaves us to reflect on ideas on what learners are to become, as suggested by workshop participants at Georgia Tech.

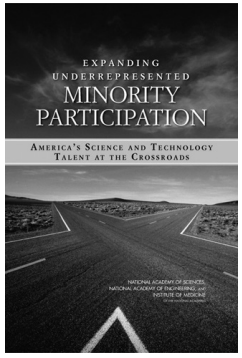
A New Biology for the 21st Century

- Purposefully organized around problem-solving this approach...brings together researchers with different expertise... coordinates efforts to ensure gaps are filled, problems-solved, and resources brought to bear at the right time.



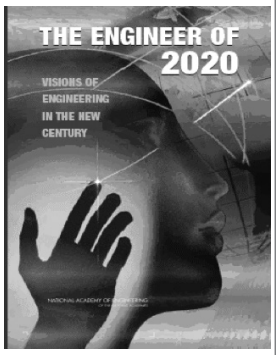
Expanding Under-represented Minority Participation

- Success may also hinge on the extent to which ... students participate in activities— such as peer-to-peer support, study groups, social activities, tutoring, and mentoring programs—that can promote academic success and social integration.



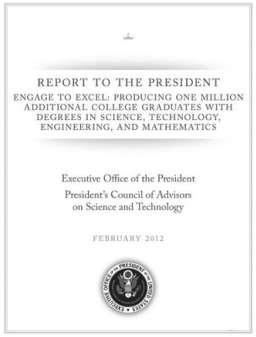
Engineer of 2020: Visions of Engineering in the New Century

- ... it will not be this or that particular knowledge that engineers (scientists, allied health professionals) will need but rather the ability to learning new things quickly and the ability to apply knowledge to new problems and new contexts.



Engage to Excel (PCAST)

- Research indicates that...compared with students in traditional lectures, students who play an active role in the pursuit of scientific knowledge learn more and develop more confidence.



What learners are to become:

- Agents of their own learning
- Able to see themselves as becoming socialized into a particular community of practice, gaining a sense of self-efficacy
- Able to address routine and non-routine problems within that community of practice

Access the Original PowerPoint Color Presentation

For full-color renditions of this PowerPoint presentation and additional slides, go to:

nsf-i3.org/conference/

Introductory Undergraduate Courses in STEM: Is Change Necessary? Inevitable?

Jay Labov

Senior Advisor for Education and Communication, National Research Council

Jay Labov points out that much of what is being talked about at this conference in terms of success is determined in large part by introductory courses and whether they serve as pumps or filters, whether they serve as gateways or pipelines. These are metaphors, he acknowledges, but they have meaning.

"When talking about introductory undergraduate courses in STEM we need to ask if change is necessary and, given all of the things we have heard here about all the different kinds of pressures, is change inevitable? If change is inevitable, then who is the agent of change? Is it the faculty? Is it the university? Is it the students? Or is it the legislature if you are in a public university? We know that an awful lot of people are calling for change in ways that faculty may not like, so I think we need to talk about these kinds of things."

Overview

- Introductory Courses as Gateways to STEM and the Liberal Arts
- Learning Research Suggests that Pedagogical Practices in Many Introductory Courses Stifles Learning and Interest
- What's Important to [Un]cover for Introductory Students?

Labov proposes to focus on three points. The first is introductory courses as gateways to STEM and the liberal arts. If students and faculty continue to think that STEM disciplines are separate from the liberal arts rather than being connected to the liberal arts we have a major problem, Labov asserts. "The world consists of the liberal arts. It consists of all of those kinds of hard problems that can't be solved only by the STEM disciplines."

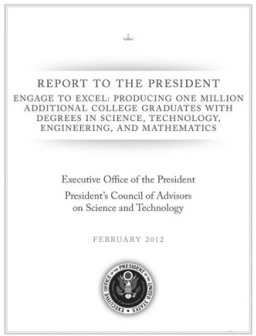
Second is learning research, which is suggesting that many of the pedagogical practices in introductory courses as well as upper-level courses stifle learning and interest. Labov recounts that when he went to graduate school and moved on to a faculty position, he was unaware that there was a literature on teaching and learning. It wasn't expected that you would know it, there was no reason to know it, there was no incentive for knowing it. Now, after more than thirty years of this social science behavioral research, "What we are finding is that a lot of things we do just don't make sense. If anything, they really stifle learning and interest in STEM subjects."

Earlier, Shirley Malcom noted that one faculty objection to trying new teaching practices is the fear that required material won't be covered. Labov repeats something he was once told: "The hallmark of the effective educator is not how much he or she covers, but how much he or she uncovers for students."

The PCAST has been mentioned several times and here Labov talks about the PCAST as it re-

> "...is change inevitable? If change is inevitable, then who is the agent of change?"
>
> *Jay Labov*

Jay Labov



2012

CURRENTLY: ~ 300,000 bachelor and associate degrees in STEM fields annually in the U.S.

FUTURE NEEDS: 1 million more STEM professionals in the next decade than the U.S. will produce at the current rate if the country is to retain its historical preeminence in science and technology.

"To meet this goal, the United States will need to increase the number of students who receive undergraduate STEM degrees by about 34% annually over current rates."

lates to introductory courses. As Nancy Shapiro reported, there are 16,000 jobs in Maryland going unfilled. Where do we get these people? One way, Labov observes, is that we just have an all-out effort to recruit more people into STEM, but the PCAST report says there is probably an easier way if we would just pay attention.

Fewer than 40% of students who enter college intending to major in a STEM field complete a STEM degree.

Increasing retention of STEM majors from 40% to 50% would generate three-quarters of the 1 million additional STEM degrees over the next decade.

Many students who abandon STEM majors perform well in their introductory courses and would make valuable additions to the STEM workforce.

Fewer than 40% of the students who enter college saying they are interested in majoring in STEM end up completing a STEM degree, and most of them leave or change their majors after the first year. When asked why, Labov explains, most students say that it doesn't speak to them, they see no relevance in what is being taught, no connections to anything else. The lectures are boring. They don't feel any connection to this community because there are 500 people in the class and a talking head in the front.

The PCAST report says that just increasing retention from the current 40% to 50%, an increase of 10%, would generate three-quarters of the one million additional STEM degrees over the next decade.

"We rationalize that many of these people who are forced out never would have made it anyway, and Shirley Malcom talked about that. But when you look at all of the traditional academic measures like GPA and letters of recommendation and SAT scores and AP courses taken, there is no statistical difference between the people who stay and the people who leave. So what we are doing is losing a whole lot of talent in the STEM disciplines, and as Shirley discussed in more detail, that includes a disproportionate number of women, minorities, and underrepresented students."

Retaining more students in STEM majors is the lowest-cost, fastest policy option to providing the STEM professionals ... and will not require expanding the number or size of introductory courses, which are constrained by space and resources at many colleges and universities.

The PCAST notes that retaining more students in STEM majors is the lowest-cost, fastest policy option. This means, Labov explains, that when you are talking to your board of regents or to your president or provost, who is worried about these kinds of things and the economic side of it, this is the most economical way to do it. You already have those students there, you already have the number of sections of introductory courses that you need. What we need to do is change the way we teach them and help retain many more of those students.

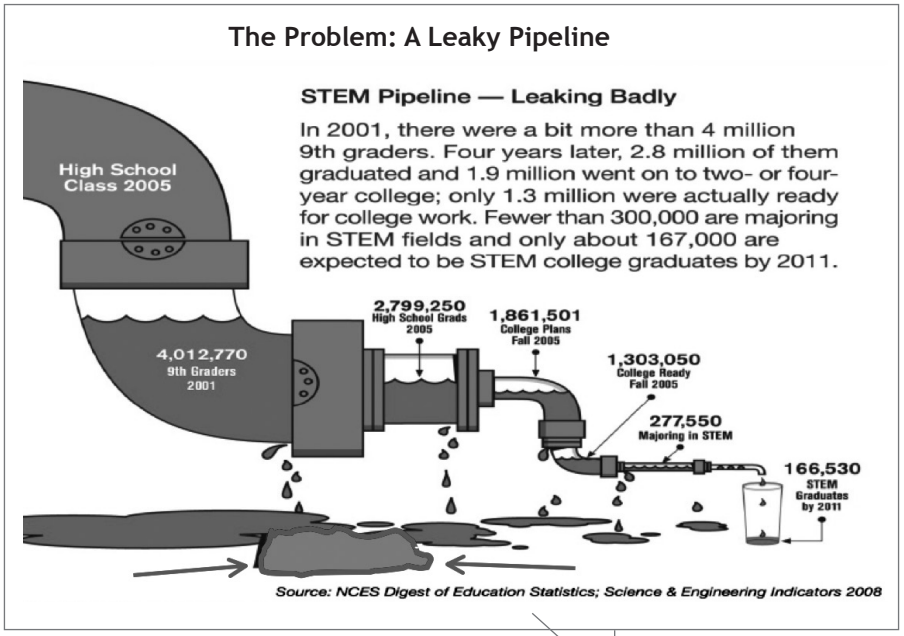
Labov turns to a metaphor all conference

participants are familiar with: the leaky STEM pipeline. Here it is represented with the high school class of 2005 with over four million of them starting as ninth graders students in 2001 and 166,530 emerging as STEM graduates by 2011. First, Labov notes, if you were in any other business than education and had these results, you would have been fired a long time ago for that loss of productivity and that loss of product.

Second, when you are talking about pipelines you are talking about a closed system: You force people in and you see what comes out. It allows for none of the things Shirley Malcom was talking about in terms of the nontraditional student, the person who leaves and then comes back. In a pipeline metaphor, when they leave they are gone and there is no way of putting them back. "This requires a different kind of thinking, from a pipeline metaphor to a pathway metaphor," Labov suggests.

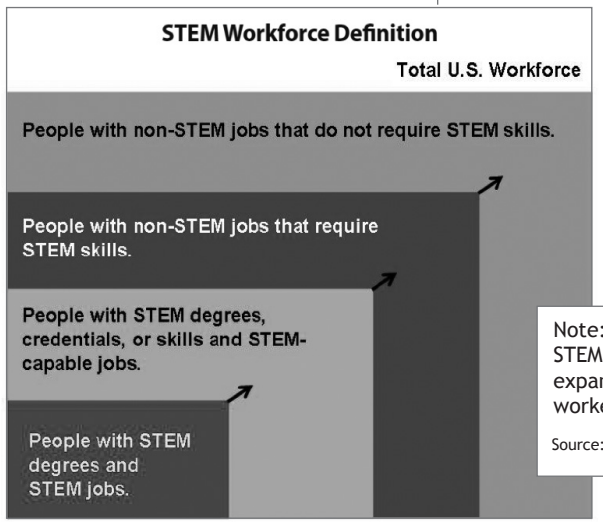
There is another element to the pipeline metaphor that provokes Labov. Look at the puddles under the leaky pipeline. Underneath those puddles is a drain. "In other words the metaphor is that all of these people who leak out aren't important and are just being washed away. Who cares about them because all you really want to do is focus on the few drops, the gems that come out of the pipeline. This is an incredible waste of resources and talent."

Labov asks, "Are those drops at the end the only people we want to produce?" In this



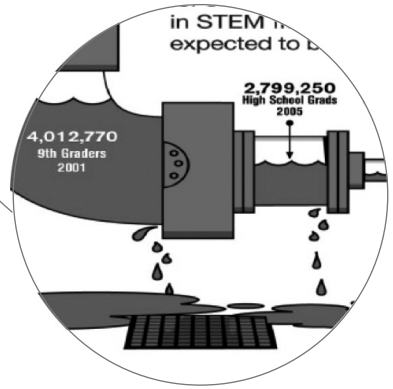
economy, at least 50% of which is driven by science and technology, STEM impacts everyone whether they are STEM majors or not.

Here, again from the PCAST report, are different ways we can think about people with STEM degrees and STEM jobs as a small proportion of people with STEM degrees and STEM capable jobs.



Note: The categories of jobs that require STEM skills and understandings are expanding, generating additional demand for workers with STEM degrees.

Source: PCAST (2012) *Engage to Excel*, Fig. F-1, p.68



> I would say everybody requires STEM skills. You make decisions about your health, the health of your family, what kind of food you're going to buy and whether it is genetically modified or not, whether you want to allow a nuclear power plant in your backyard...STEM is important for everyone.
>
> *Jay Labov*

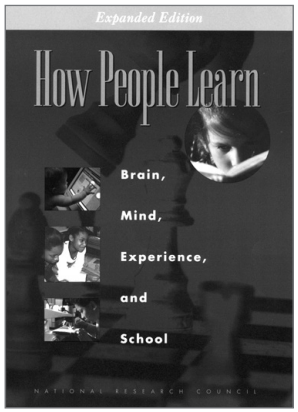
This includes, for example, people going into environmental law who have some background in science, engineering, and mathematics to make rational decisions about what they are doing. These are people with non-STEM jobs that require STEM skills. Labov himself worked for 18 years in Maine at Colby College. Early on he visited a nearby paper mill and saw the type of factory line that Daniel Goroff talked about. Eighteen years later he went back and those people weren't there anymore because they no longer had the skills required. They needed math skills and they needed computer skills.

"The world is changing," Labov states, "and there are a lot more people we have to think about, and we have to think about what constitutes success in STEM education." If an art history major comes in and takes Labov's non-major STEM course and thinks it's pretty interesting and wants to take another one, to Labov that is a huge success. But how does the university or the department and its infrastructure hamper that kind of thing? For most non-STEM majors, before you can take that upper level course in physiology that really interests you, you have to go back and take the introductory course for majors, which is what you're avoiding in the first place.

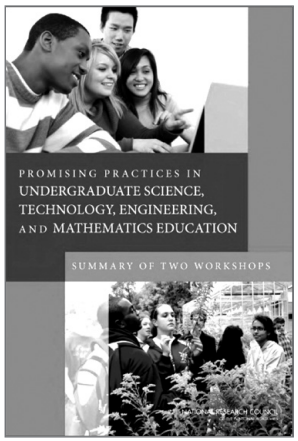
"It is how we begin to think about how the introductory course affects everything else and is influenced by everything else," Labov says. "And then in terms of that larger group that doesn't require STEM skills, I would say everybody requires STEM skills. You make decisions about your health, the health of your family, what kind of food you're going to buy and whether it is genetically modified or not, whether you want to allow a nuclear power plant in your backyard when we know that nuclear power plants are going to help us with global climate change. There are trade-offs. How do you analyze these kinds of things?" STEM is important for everyone, Labov reiterates, and because most students will never go beyond the introductory course, what we need to figure out is how to transform those introductory courses.

We want to get back to how people learn and the evidence-based kinds of things highlighted in these two reports from the National Research Council. "What we know is that, for the most part, we are doing things wrong," Labov observes. He challenges participants to figure out

- *How People Learn*
  National Research Council
  2000
- *Promising Practices in Undergraduate Science, Technology, Engineering, and Mathematics Education*
  National Research Council
  2011

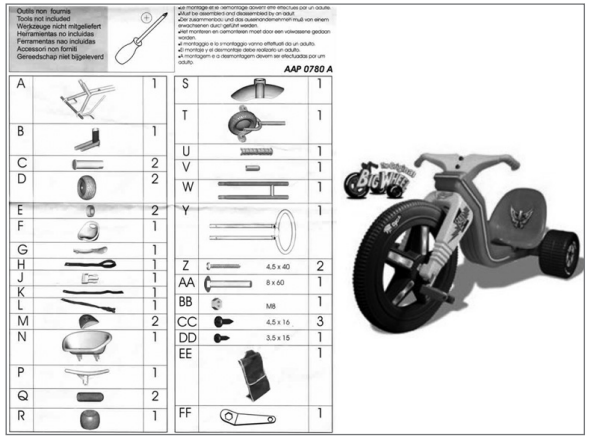


National Research Council
2000



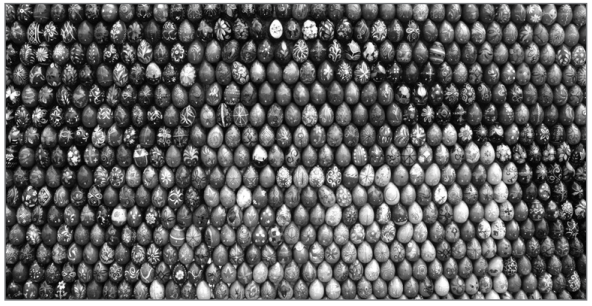
National Research Council
2011

what the instructions at left below are for and then reveals the picture of the Big Wheel.



Until you see the picture of the Big Wheel and what the big idea is, it is really hard to figure out what those instructions are for, he points out. First, it doesn't tell you the size of the parts. "We have students who look at things in biology textbooks like prokaryotic bacteria, which are hundreds of times smaller than eukaryotic, but the textbook leaves it to students to figure this out.

Another example is a photograph Labov took in Rome, and he challenges participants to figure out what this is.

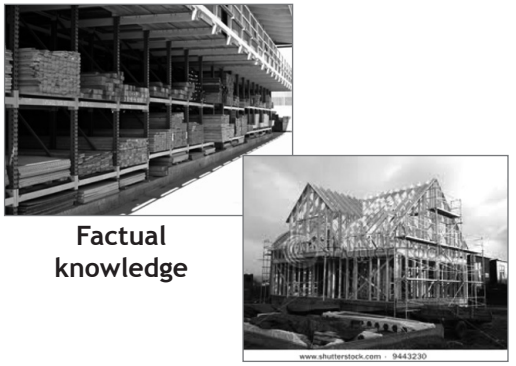


Once you see the whole picture you realize what you are looking at is a mosaic composed of decorated eggs.

"We fail to do this in introductory courses because we are so busy giving the factoids of the content that we don't help students see the bigger picture and how the factoids fit in," Labov explains. "We really need to fundamentally think about these things. We have to think about the difference between factual knowledge, the parts that we use to build things, and the conceptual framework and how that can actually develop. In the breakout group we can spend more time talking about how people learn and how that affects introductory courses.

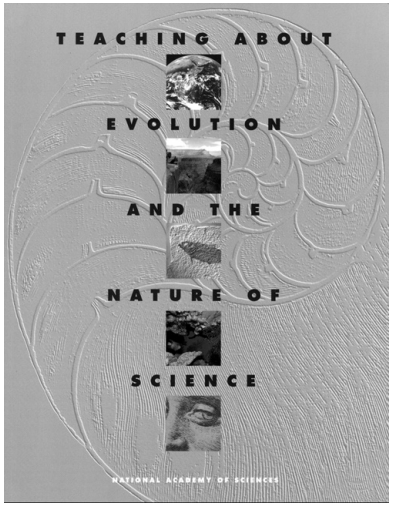
Labov refers to an NRC report done in 1998 for high school teachers who were having trouble dealing with evolution. In looking at this, Labov decided the title was backwards. "What you really need to be thinking about is how the students understand the nature of science, and then evolution can be part of that, but we are so busy telling people what the facts are rather

BUILD BOTH



Factual knowledge

Conceptual framework



Interconnections and Initial Thoughts

• When we developed this agenda we thought we had four distinct topics on this panel, but in fact they each strayed into each other's territory. That is because these are complex issues and by their very nature, they will stray. I think the reason why they are interconnected is because underneath them all they are all talking about how do we achieve a vision for learning. That vision for learning undergirds every one of these topics, whether it is about administrative policy, spaces, courses, or the context for evaluation.

I also heard a lot about promoting success and how that relates to a student's identity, especially in Shirley Malcom's keynote talk, and that is an important issue that affects how they learn, where they learn, the courses in which they learn and how they are taught. I heard the thought that STEM needs to relate to the arts. STEM also needs to relate to students' perceptions of themselves.

In thinking about the question of what it means to retain students, what does it mean to retain motivation? Students come in motivated. How do we retain that motivation? • **Joni Falk**

than how we came to know this, what was involved, what were the human dimensions of all this."

Listening to some of the focus groups for another book the NRC wrote on evolution and creationism, Bruce Alberts remarked, "The people in that focus group just see science as another form of revealed truth." That is the way we teach it, Labov points out, so of course they see it that way.

"So we need to fundamentally rethink what the nature of the introductory course is, given that 80% to 90% of those students will never go beyond that. Is it important five years from now for them to remember the difference between the second and third laws of thermodynamics, or what a controlled experiment is and what data means and what risk means?"

Breakout Session Previews

• I'd like each of the panelists to talk briefly about what it is they hope will come out of their breakout sessions. • **Joni Falk**

Communally Addressing How Learning Happens

• When we think about learning spaces, there is a question behind, "What do we want our students to become?" That is thinking about how learning happens, which is a powerful question that really gets a community together to think about the becoming and the spaces and the experiences. In the past six months I have had workshops with what were primarily facilities officers. You sit there with two teams of facilities officers at a major state university and say to them, "The first conversation we're going to have is how does learning happen." At first their eyes glaze, but this is the best group to talk about how learning happens. They learn by doing, and so you can distill their experiences. There is learning by failing, and so on.

I think the campus community that addresses the question and arrives at a communal sense of how learning happens can guide all of the other institutional change things. • **Jeanne Narum**

World Cafe re Policies and Practices

• We are going to be running a world cafe kind of event. It scaffolds knowledge from one group to the next group, and so on. We have what we hope are some provocative questions around how those of us in various positions in the university, some more powerful than others, can actually effect the changes that we need to have happen, knowing all of the current constraints that exist in the university structure. What are the strategies that we can

learn from each other and how can we help each other find ways around those particular impediments? • Nancy Shapiro

- It's easy when we start talking about policy issues to think only in terms of barriers. I would hope from our conversations in our session that we also come up with some opportunities and ways in which we may be able to change policies or capitalize on what we know about each other's policies and procedures in order to loosen the opportunities that we have, in addition to overcoming barriers. • M.J. Bishop

The Exclusionary Way STEM Introductory Courses are Structured

- One thing I didn't talk about because of limited time, but hope we may get into in the breakout session if people are interested, is the way that the STEM disciplines are constructed, which is very different from any other discipline. If you think about introductory courses in geography or government or sociology, there aren't separate courses for majors and non-majors. At Colby College, as chair of the science division I didn't understand at the time why the government department would allow students who had taken an introductory level course to take a 300-level course immediately after that, whereas in the sciences you had to take 100 and then 200 and then 300 because there was this supposed progression (though students always forgot everything after they took the last course so you ended up having to review half the stuff).

  There are some real implications to what happens when you sort people by majors and non-majors. I would like to have people explore, if they are interested, what the implications are for essentially moving people out at the very earliest stages, or requiring them to major in this or they can't do anything else in this discipline, even though they are really interested in it. What does this say to their own sense of who they are, what they're capable of doing, where they can go through these institutional pathways? There are all kinds of interesting dynamics that go on with introductory or gateway courses that I think need to be explored beyond what we teach in them. • Jay Labov

Living by Our Principle of Providing Evidence, Designing Evaluation Up Front

- I often think about the fact that we are always teaching more than what's on the curriculum and that students learn an awful lot from the way that we shape our institutions and the way that we conduct ourselves. It is therefore really, really important to live your principles. We are here to talk about science, and when we talk about the principles of science we often think about evidence, about experiments, about methodologies. But we don't often actually use those very well, neither in our science nor in our education.

Missing from the Equation: Introduction to Engineering/Engineering Literacy

- I want to put one idea before the panel that I find very troubling. That is, in most institutions the only people who ever have access to engineering concepts are engineering majors. Given the increasing importance of engineering within the broader contextual framework that we face, where is the introduction to engineering and engineering principles? I know that the *Next Generation Science Standards* are supposed to incorporate it. I have no idea how anybody thinks that is going to happen given the lack of knowledge and lack of access to engineers within the K-12 structure. But I do think it is going to be a major barrier to this larger set of literacies and understandings.

  There is a fundamental question about whether there are whole missing pieces of thinking and conceptual design. I think there is a general acceptance of the fact that everybody needs to know something about programming even if they don't become computer science majors, but I don't hear a lot of conversation about this other issue. • Shirley Malcom

If you saw the front page of the *Economist* not many months ago, many published scientific studies out there, especially ones that concern health and ones that are pretty important to us, turn out to be wrong. They turn out to be wrong because people haven't paid enough attention to the design of experiments, to the statistical kind of methodology, and to simple principles. I am not talking about all sorts of mathematical formulae, I am just talking about how you make comparisons in an organized way and how you worry about sampling bias and how you worry about publication bias. It's not just implicit bias, although I think the implicit bias work is really fascinating and important also.

In the breakout session, I want to take some examples of programs that you have either run or are considering running, because if you are already running it, it is probably too late. You'll be going down the hall to the administrator, like I was at the Sloan Foundation, asking them if they've collected data that is now gone. You want to design these things up front so that you have the proper controls, the proper sample sizes, the proper kinds of comparisons, as fast as you can. It's not always possible, but the more thought that you give to that, the more that we will be able to live up to our principles of providing evidence, doing careful experiments, and really being able to argue about methodology.

• **Daniel Goroff**

FUNDERS PANEL: VISIONS OF INNOVATION

Session Overview

Daniel Goroff, Facilitator

Vice President and Program Director,
Alfred P. Sloan Foundation

Goroff explains that the speakers are here to talk about the process of grant making. "Usually when funders talk, we talk about the design and the development and the evaluation of proposals. We thought instead we would talk about the design and the development and the evaluation of our programs. We, too, have to think about how good a job we are doing and how we develop our priorities and so on." In this session each guest speaks briefly about the process at their institution and the session then opens up for questions and discussion.

National Science Foundation

Susan Singer

Division Director, National Science Foundation

Noting that each of the speakers work in a different kind of environment, even though they have shared goals, Singer begins with an overview of the context in which decisions are made about the overall National Science Foundation portfolio in undergraduate STEM education, followed by some thinking about where that portfolio is heading.

At the NSF there are many people who have input into the foundation's direction, and they listen carefully to the community represented by those gathered in this room. At any one time they are working on three different budget years simultaneously and currently are already planning for fiscal year 2016. The budget for 2015 starts out with the President's requested budget, and it is the Office of Management and Budget that works with NSF to set that. The actual budget is decided by what goes on in the House and the Senate.

Education and Human Resources is a little different from the other research directorates that are all grouped together in one funding line at the NSF, Singer explains. There is a separate funding line for Education and Human Resources and much of that budget gets specified down to the level of programs. "So we are always balancing how we can move forward in good, creative ways with the good and creative ways others have in mind for how we should move forward."

That said, Singer continues, there is some very interesting momentum across EHR, across NSF and across federal agencies. "It is a really critical time. We are at a tipping point for moving STEM education forward, and we are able to do that by building on the existing evidence base and also with all of the work we invest

"It is a really critical time. We are at a tipping point for moving STEM education forward, and we are able to do that by building on the existing evidence base and also with all of the work we invest in generating new knowledge."

Susan Singer

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Common Guidelines for Education Research and Development

Released by the Department of Education through the Institute for Educational Science and the National Science Foundation. For more information and to download:

http://www.nsf.gov/pubs/2013/nsf13127/nsf13127.jsp

in generating new knowledge." There are new *Common Guidelines for Education Research and Development* that have been released by the Department of Education through the Institute for Educational Science and the National Science Foundation that offer very good guidance, Singer notes. "That is one example of the kind of coherence we are aiming for. We all have bags of carrots of different sizes to invest and we are motivated by really moving the needle on improving the quality of undergraduate STEM learning in this country, and that does require some coherence."

Within the Division of Undergraduate Education there is a new Improving Undergraduate STEM Education program which pulls together the best of three very strong programs as well as new opportunities. "We have a framework we are working in across NSF so that all of us in different directorates are leveraging our efforts to push hard on improving the quality of the learning experience, with an eye to a more inclusive approach, broadening participation and increasing persistence and retention in STEM fields," Singer explains.

Looking across the federal agencies, the five-year strategic plan for STEM education rolled out in May. "I had the good fortune to convene the folks across the 13 federal agencies that are working on undergraduate STEM education and we are working on implementing that strategic plan," Singer reports, noting that there is a lot of fall-out, and a lot of coordination is required regarding how to collectively push on a common goal in a way that is coherent for those out there putting in their best efforts in isolation.

A last piece of interest to those at this conference is a letter Cora Marrett sent out to the community, talking about increased efforts at the NSF on transparency and accountability. "We are working across the NSF on the way our public abstracts are put together so that it is really clear to the public both what we are trying to do in a non-technical way so that everyone can understand, as well as the technical details that build on that," Singer relates. "And we are doing a lot more work with portfolio analysis, looking within programs, across programs, across divisions, and across all of the NSF. How can we describe where we are making our investments? We are looking both at our active portfolio, what are we actually funding, but then at all of our planning. What is our aspirational portfolio? By having that actual data we can see how we can move forward a little more quickly and a little bit more effectively. Those are some of the key areas we are working on for greater coherency and greater impact and effectiveness in our investments," Singer concludes.

Helmsley Trust

Ryan Kelsey
Program Officer, Helmsley Trust

Ryan Kelsey notes that the Helmsley Trust is new, based in New York City, and the Leona and Harry Helmsley real estate fortune serves as the asset base for the trust, which just celebrated its fifth anniversary and granted its one billionth dollar. Much of the work of the trust is in health and medical research, and it is the largest private donor for healthcare in the upper Midwest. The trust also has a sizeable new education program with a national focus. Kelsey joined the trust 15 months ago at the start of strategic planning for the higher education work. "I thought of it as joining a startup," Kelsey observes, "and in fact that is what it has been like for the past year or so, and I have the blessing or curse of being *the* program officer for higher education. There is no one else. I have a terrific program director who works on our K-12 program and helps me as best he can. So where are we, why did we decide to do the work that are we doing, and what is our work?"

The board gave Kelsey and the education program two broad themes, he explains. "One was wanting Americans to be competitive economically around the world and to do whatever we could aspirationally towards restoring some upward social mobility for those with less opportunity." With that in mind, there was an interest that coincides with the timing of what is going on in STEM education that Susan Singer noted. The idea of helping more students persist and complete in STEM areas at all levels of higher education, from community college and technical schools up through comprehensive research institutions, really resonated with the board. It was Kelsey's task to determine the strategies that might be employed, given the $30,000,000 annual education budget, about a third of which is devoted to higher education work.

This is small in relation to what NSF is doing, Kelsey observes, "So what could we do that would be complementary, distinctive, and appropriate, and something our board would be comfortable with? We latched on to a lot of the great work that has been done over the last 20 years or more to identify really powerful innovations and known practices that will help people persist and complete in STEM, and I suspect many people in this audience contributed to that. For us the innovation part of the work was less about figuring out what works than trying to figure out how you could get widespread adoption. We started doing more talking and listening and interviewing, and I interviewed many of the people sitting next to me as well as their colleagues about what we might do and how we could be most effective."

The effort settled on the question of what are the barriers that are stopping people from being able to persist and complete, and on two main strategies. One is "practices work," about changing how the gateway STEM courses are taught. "While there is a lot of evidence about

Ryan Kelsey

what to do, there is less evidence about how to get lots of departments and lots of different types of schools with different characteristics to do this in a transformative way," Kelsey observes. "So a lot of our grants are networks of colleges. Sometimes that is in associations and more formal structures, sometimes it is in more ad hoc structures. The experimentation that we are doing is about how to get this systemic change to happen. What are the levers? Is it cultural, as one of the breakout groups here is focusing on? In some cases we are also really interested in the broadening participation element. In any case, what are going to be the networks that will have the most impact?"

The other side of it involves building on work that other private foundations have done on the college success agenda in general. Lumina, Gates, and others have changed the conversation from access to completion. "For us the question is how can we build on that and not just replicate what they are doing," Kelsey states. "The question is, completion for what? Not just to get a credential, any credential, but state a value proposition that some credentials may be better for the country and better for certain people than others and can tap talent out there that should be taken advantage of. We do some work also on policies and systems and models of practice that have to do with advising, course sequencing, research opportunities, all of these other pieces besides instruction that may be more structural in terms of how colleges do or do not help more students persist and complete.

"That is essentially the theory of change, if you will, of what we are trying to get done. How are we going to know if we are successful? We actually try to write down some metrics and set some targets for what we are going to measure, and it relies on certain assumptions that I think you will be familiar. I will just say one of them. It is our feeling that if we can get a lot of what we will term 'active learning' happening in the introductory STEM courses, then we might see more persistence if you believe that one of the main barriers is poor instruction in those courses. If you believe that more persistence leads to more graduates, then maybe we can say that if we could get two million more student seats of active learning in this decade, maybe we could get another 100,000 graduates. If you believe the PCAST *Engage to Excel* report, that would be about 10% of the projected shortage."

The approach is grounded and pragmatic, Kelsey explains, noting that the Helmsley Trust is not an academic community. They are talking in layman's terms about what this would mean, which makes it understandable for the board and the other program areas. "And we will constantly be iterating and moving on this as we learn from our first set of grants," Kelsey notes.

"While there is a lot of evidence about what to do, there is less evidence about how to get lots of departments and lots of different types of schools with different characteristics to do this in a transformative way."

Ryan Kelsey

Howard Hughes Medical Institute

Cynthia Bauerle

Assistant Director, Undergraduate and Graduate Science Education Programs, Howard Hughes Medical Institute

"Listening to my colleagues," Bauerle says, "I think it's significant that although our approaches are different because we are three different kinds of organizations invested in STEM higher education, our focuses are very well aligned, and perhaps they should be if indeed the investments that we make from our different organizations are ultimately going to move the needle on science education reform."

She then talks about the approach at Hughes, focusing on undergraduate STEM education. The Howard Hughes Medical Institute is primarily a research institute and the mission is to support the innovative cutting edge of biomedical research in this country. This is achieved through support of over 350 investigators working in labs at research universities across the country.

"Our interest in science education has to do with our investment in the future of biomedical research," she explains. "The charge of our group is to guide the strategic investments that we make to address the issues that will ensure that we will continue to have the kind of intellectual and scientific leaders that we need in this country to sustain our US science enterprise."

That is a big goal for an undergraduate science program, Bauerle acknowledges. The programming aligns around two strands. The first relates to the science education infrastructure: the institutions where science is taught and the people who are teaching science. The second has to do with the future generations. "We are very concerned, as is everyone, about ensuring that we access the talent pool that we have in this country and that our scientific enterprise is populated by scientists who are representative of the country."

Because Hughes is a research institute, not a foundation and not a funding agency, the approach is that of an experimentalist, Bauerle explains, noting that she, her boss David Asai, and about half of the people in their group are academic scientists. "As we think about managing our investment, which is modest compared to other funders, it is really important to think about how we can make the most of the resources that we are pushing out into the community. We think the best strategy for us is to look for high potential kinds of initiatives, which are often high risk. I think addressing student persistence in the first years of undergraduate education is a grand challenge and an important one. We are looking for ideas and people and innovations that we think will change the landscape and make a significant contribution."

This is "informed risk taking," Bauerle notes. "One of our goals is to make sure that everything we design is informed by broader conversations—those are conversations with funders as well as with the academic community—and also informed by the scholarship that

"We think the best strategy for us is to look for high potential kinds of initiatives, which are often high risk. I think addressing student persistence in the first years of undergraduate education is a grand challenge and an important one."

Cynthia Bauerle

Cynthia Bauerle

directs how science education and the teaching and learning that happens in the STEM context is done in the best ways.

"The final principal I will share is that we see our resources as best utilized when they are utilized as catalysts rather than as sustaining projects. Rather than a project that would need to have significant external funding for a long period of time in order to sustain it in the context of an institution, we are really interested in ideas that try something out to see if it works and to see if it's something that can become ingrained into an institution."

"Finally I want to talk about dissemination, which I think can sometimes get stuck in a backwater of thinking that the point of funders asking grantees to disseminate what they do is so that they can tell the funders that they disseminated what they did. Again, because we are an academic research institute, we are interested in the scholarship of what our programs are doing. So if from that summer bridge program emerges an innovation that is particularly potent at engaging students to understand why quantitative skills development is important, that's a piece of information that ought to be disseminated, it ought to be contributed to the conversation so that we all learn more about how to do things well.

"So I think the balance of practice and scholarship is one of the unique features of our program. It is a luxury for our programs, but one that we are constantly trying to focus in order to leverage our investments the best that we can."

HHMI: Evidence of Program Impact

Bauerle turns to the question of how her group knows if its programs are working. "We have a board of trustees and they are very concerned that the investments are being used wisely. The question that we are always seeking information about is: How do you know your science education programming is having an effect? How do you know it's having an impact? We give grants to research universities, we give grants to primarily undergraduate institutions, and we give fellowships of various types mostly to students, but we also have the HHMI Professors program. How do we know that these programs are having an impact?"

The explicit expectation of regular grantee reporting on activities, participation and outcomes is a big part of the evidence stream, Bauerle notes, "But we are really interested not so much in the success of a single institution. If we've done our jobs right we have selected institutions that have the highest potential to try something new and learn from it and figure out how to make it work. We are interested in how the collection of institutions that we fund in a program designed around a particular objective are actually moving toward that objective.

"So in addition to the project activities on the ground, which is part of the daily focus of our grantees, we are really interested in what they are learning and what that is contributing to a broader conversation. Whereas it is important to know that a summer bridge program that is positioned as an intervention to target math preparation in incoming freshmen is doing its job in preparing those students for college-level math learning and college-level science learning, we are also interested in what that program is teaching us about how we prepare students quantitatively for success in undergraduate science education.

"We are interested in observations and evidence of changes of practice, institutions that try something and because of what they learned they start doing something differently. We are interested in institutional investment, that projects that are piloted become part and parcel of the function and structure of the institution, sometimes called 'institutionalization.' We are interested in synergies. What can our efforts do together that they may not have been able to do in separate units?"

Questions & Answers

Starting/Changing/Ending Funding Programs

- We have all found ourselves in conversations

where someone has a very good ideas, but the funder says, "That's a very good idea, but it's not within program." But sometimes those programs change. I'm thinking about programs as the overarching umbrellas that projects sit under, the bins that they have to fit into, and sometimes those change. I'm very curious about the process of change. How do you start up a program at your institution and how do you end one? • **Daniel Goroff**

National Science Foundation

- In the Division of Undergraduate Education we went through this in a really big way this past year. When the 2014 budget came out it became clear that with three of our long-standing programs, Transforming Undergraduate STEM Education, the STEM Talent Expansion Program (STEP), and Widening Implementation & Dissemination of Evidence Based Reforms (WIDER), it would be advisable to think about them in a more cohesive, integrated way. In the 2015 budget, across the NSF, you will be submitting proposals to the Improving Undergraduate STEM Education umbrella of programs.

  That is a pretty huge change for the community, it's a pretty huge change for the fifty-some of us who are working together in the Division of Undergraduate Education, so a little bit about the process. We did a lot of, "Hmm, what does that mean for us?" People expressed their feelings, there was a little bit of mourning that probably wasn't just in the community, it was in our staff. We don't waste much time with that kind of thing at NSF, so we got down to thinking about what we were going to do next. Unlike Ryan, where there is one person who can think up great thoughts and move ahead, we need to do this with our team. We started having a lot of conversations with each other and then we did a number of rounds of writing white papers in teams, with different disciplines covering the social sciences, all of the different sciences, and engineering. We had groups that wrote white papers on the core principles under which we were operating, the end goal, and what it might all look like. Then we did what you would do in a classroom, we did a jigsaw where representatives of different white papers got together and shared their ideas, and then those teams collectively wrote white papers. Then we wrote a number of different drafts. There were some complications regarding what form those could actually go out in to the community.

  In parallel we were having conversations with our colleagues across NSF, so we were having lunches and brown bags (which at NSF can happen at three in the afternoon with no lunch involved). We listened to everybody and we kept working on this, and besides our program description we came up with a very exciting idea for us to work across the research directorates, using something called Ideas Labs. There is one in engineering looking at social quality issues of broaden-

Cross-Foundation Communication

- People may not realize that foundations and agencies do communicate and we really are trying to collectively leverage what we are doing. We've had some wonderful projects that we've done with the Howard Hughes Medical Institute. • **Susan Singer**

ing participating in engineering, so maybe in a few years, for example, there will be more women taking engineering than when I started out as an engineering undergrad. And we have one coming in biology pushing on the math and computing pieces. It has been very exciting, but it involved bringing together a lot of players, sharing ideas, letting go of things, embracing new things, and getting on board. • Susan Singer

Sustaining vs. Catalyzing

- Back in the day when I was a young man, I came out of high school and didn't get all of the math that I should have. There was an NSF-sponsored summer program, which essentially was a bridge between high school and college, and that's how I ended up in science. Almost every person I can think of who participated in that program is in some area of science, including medical doctors and PhDs. It seems to me, when I contrast that with my interactions with HHMI, when NSF finds something that works they abandon it right away and go on to something else. Unfortunately, the nature of NSF-funding is that many established programs with demonstrated successes aren't continually supported over long periods. • Isiah Warner

- I would agree with some of what you're saying regarding summer programs, but I don't know about the long-running. We just celebrated the 60th anniversary of our Graduate Research Fellowship (GRF) program. Our Research Experience for Undergraduates (REU) has been in place since 1958, aside from a brief hiatus when President Reagan decided we didn't need to fund education at the NSF. In terms of these bridge programs, I see them all over the place. Something parallel is when I hear people say, "NSF got rid of GK-12 and it was an amazing program." Well, we got rid of a program named GK-12, but it's wrapped into a lot of other programs. There are all sorts of bridge programs through the LSAMP program. In what was the STEP program, that is now in IUSE, there are tons of bridge programs. This was actually a special focus with funding from INTEL and GE. Washington State and the University of Washington put together a redshirt model for students coming from under-resourced high schools into engineering. ("Redshirt" comes from sitting out a year in sports.) • Susan Singer

- The point I'm making is that these are watered down versions of what I went through, they're not the strenuous sort of things that are not only background-building but also personality building, confidence building. We were taking calculus in the summer bridge. Before attending that program, I had never even heard the word 'calculus.' • Isiah Warner

- That's exactly what the redshirt model does, get students ready for calculus. We can all have our opinions about the programs that are funded. I spent yesterday at the University of Maryland Baltimore and one of the core things in that Meyerhoff model is that summer bridge program. The staff there would state that is key. • Susan Singer

- I agree, but NSF is not funding that. • Isiah Warner

- That speaks to Cynthia's point about catalysts. You figure out great things, and if we used our money to sustain every great innovation, we would have a budget where we could maybe buy a pencil for every undergraduate in the United States, and that's not going to help us move forward. We invest in figuring out how things work. One of the clever things I think we are doing now, and I hope it is also positive and productive, is the I-Corps model. We have adapted that into something called I-Corps-L, I-Corps for Learning. We have worked with nine teams that had very exciting and promising innovations, set up teams to help them figure out how they could spread their work to develop the skills which most of us don't have. Most of us don't have an entrepreneurial background. Built into that model is "No, we are not going to give you additional funding from NSF. We are going to help you figure out what other resources are out there and how you can go forth and develop a plan to sustain what you do." That is essential with all that we do. We cannot develop something for five years and then for the next 50 years pay someone to keep doing the same thing over and over. The math doesn't work. It's not that it's not a great thing, but we're catalytic. It's a philosophy that I think is shared with my colleagues at the table. • Susan Singer

Howard Hughes Medical Institute

- For us it certainly is true that programs do and should have lifetimes, so they should have beginnings and they should have middles and they should have ends. What doesn't change so much for us are the broader objectives. I will give two examples to show how we think about this: pre-college STEM education and the HHMI Professors Program. The HHMI Professors Program has existed for over a decade. The Professors Program is our attempt to address a very specific challenge, which is the pervasive myth, grounded in some degree of reality, of poor teaching quality at research universities across the country. The idea is that because of the tensions and challenges of balancing research and teaching missions at institutions and how those tensions translate to faculty, ultimately means that the faculty who are standing in front of the majority of undergraduates who are getting STEM degrees in this country are not

Students with Disabilities

- One of the things Shirley Malcom said during her keynote address is that there is a need for mainstreaming, making sure that underrepresented groups are included in everything that we do, and there is also a need for targeted projects for people who are in groups that are underrepresented. I'd like NSF to address these two areas regarding people with disabilities. •Participant

- Twelve percent of all undergraduates have a disability and it is really important. Research for Disability Education (RDE) didn't go away. • Susan Singer

- But it is only the research part that is maintained, which is a really tiny part of the original RDE project where we had alliances and demonstration projects and dissemination projects. Everything from RDE went away except for that tiny little part that is very specifically focused on research. I am talking about that other part. There used to be under RDE a program very similar to LSAMP, focused on students with disabilities. •Participant

- Just to be clear, the gender studies and the research on the RDE grant persist. They've moved from HRD and they're not called out in the same way. They've been wrapped into the REAL program, and then in 2015 that's getting wrapped into the EHR core research. I was worried from your question that people hadn't tracked where it went. And yes, NSF is a research agency and NSF's motto is "This is where discovery begins." Now research doesn't mean that there is not design and development, that there are not networks. I think there is a huge amount of confusion right now in the community. People are saying, "EHR is becoming a research directorate. I don't fit, I don't belong." That is absolutely not true. Education research is about designing interventions, building tools, and figuring out what works. Again, it goes back to the catalytic question, but it is an iterative design and development process. • Susan Singer

very well trained and are not very committed and are not doing a good job. I think that's a pervasive myth. There was a white paper that had a big influence on us several years ago, a study that came out of the Nature Publishing Group, about this issue of the perception of teaching standards at research universities.

What we recognize, of course, is that there are individuals who really challenge that myth, who are themselves accomplished scientists and also scientists whose creative intellectual capacities are focused on their teaching just as they are focused on their areas of research. And so the HHMI Professors Program gives awards to individuals who are exemplars in their departments, at their institutions, and because almost all of them have national stature in their scientific communities, at that level as well. The point is, if we give support for those accomplished scientists to be able to pursue their most interesting ideas about science education, what will we get from that? It turns out what we get are really good projects.

We are right in the middle of a competition to identify a third cohort of HHMI Professors. It is a very exciting competition because we are expanding the disciplines beyond biomedical sciences into physics and chemistry and engineering. The goal is to identify scientists who are accomplished in their own disciplines who have interesting ideas they would like to pursue in science education, and we give them support to do that. We actually look at the professors we have funded in the past 15 to 20 years and it turns out that if you provide financial and structural support for accomplished scientists to do science education projects, it doesn't detract from their research and their scholarship. What it does do is expand their scholarship into areas that have an impact in science education.

What I'll say about that program in particular, going back to my comments about innovation and catalysis, is that the grants we hope to award to this new cohort will be one-time, five-year awards. The idea is that we will make a solid, significant investment in an individual and their good ideas for a defined period of time so that from day one, part of

HHMI: The K-12 Challenge

- For 25 years, Hughes has had a quite substantial commitment to pre-college STEM education which, if there is such a thing, is a harder problem that undergraduate STEM education—the K-12 challenge.

  We had a program that was dedicated exclusively to funding projects that were targeted at pre-college populations and we had a number of higher education institutions over the years that have been funded for pre-college activities. In the past couple of years we have re-evaluated our commitment to K-12 STEM education, which is unwavering, and asked ourselves the hard question of how our investment is having an impact on a broad scale and how we could improve the investment and its potential to have an impact. The outcome of all of that was that the pre-college program, which has run for 15 or so years, ended in this past year. Our focus in our institutional grants has been clarified in the past couple of years, so the pre-college kinds of activities are much less prevalent in the grants that we are funding.

  But what we have done is commit substantially to the UTeach program, which trains STEM teachers. We spent a long time looking at teacher preparation and trying to learn about the world of teacher preparation and decided that the best investment that we could have, given the small amount of resources that we have, could be amplified if what we did was to focus on the preparation of teachers to go into classrooms, and in the course of their careers touch thousands and thousands of students. • **Ryan Kelsey**

the conversation is how do you pursue this idea in a way that will allow you to sustain it as you go. • Cynthia Bauerle

Helmsley Trust

- Give the newness of our program I'm not sure I can respond to this question exactly, except to say that I hope we live on beyond our first year. At the risk of using mixed metaphors, I sometimes hear that trying to move something like the NSF is like trying to move an aircraft carrier, you are steering this big thing. I am surfing. I'm on my little surfboard but the wind could change, bad weather could come, a lot of things could happen, so I move very cautiously. Because the education group is changing its focus from what used to be a little New York City program to a big national program, we could be the guinea pigs, or to put it in a more positive light, the pioneers for the other program areas about how to elevate how Helmsley does its deci-

Risk, Failure, Adaptation

- What percentage of your projects do you hope don't work out, in terms of risk? Do you expect all projects to work, or is it okay if some of them do an evaluation study and don't get significant results, and how do you deal with those institutions? • Joni Falk

- The mantra at Hughes is "People not projects." I think that helps us remember that all of these projects are really the implementation of an idea, pursuit of a question, or pursuit of an objective. So I guess I'd answer that question both ways. Projects fail, that certainly can happen. Our interest is not so much that we want to sit back for the four years of the grant and then you tell us at the end what happened and try to share with us the best face that you can. Rather we would like to think that we are in communication, we are in conversation with our grantees from the first day of the award, and that if something gets launched and 16 months in you say something has changed in the landscape or you didn't think of something and you know that running this for another two-and-a-half years is not going to help, then the conversation becomes what can you do, how can you change this, how can you modify it. We try to protect the flexibility of the grants that we fund in order to be more responsive to those kinds of things. And we do have grantees who stop projects midstream because they aren't working for some reason, and then we have a conversation about how those resources get funneled differently for them so that they can pursue the same objective doing something else. • Cynthia Bauerle

- We even have categories of grants that we push even harder on high risk kind of awards. EAGERs, for example, the early exploratory types of grants that are out there. When you talk about risks, that is exactly what Cynthia was saying. You take risks when there is a high reward, not because it's a mundane project that might or might not work out. That's a really important distinction. There are other things that look very promising and don't work out. Rarely does this happen at NSF, but many grants as you know are made on a year-by-year basis and if it is really not working out there may not be a next installment, but that is so rare. And that is really different from: "This is the coolest idea and we know it may not work, but we really need to try it." So we balance the portfolio. I think it's impossible to say there's an absolute percentage, but people get really excited about some of those, the high rewards ones, not just the high risk. • Susan Singer

- This is a testable hypothesis in my group, but we have been told that if a fair number of things that we are doing don't fail, then we need to increase the risk calculation. We adopt the same approach with our grantees. I don't know if I would call it intrusive, but we are not there to sit back idle, we are going to be involved and try to make everything successful. Nonetheless, the idea is to take some chances. • Ryan Kelsey

sion making to be more evidence-based and less about relationship building.

When I was in the shoes of having to do fund raising myself, I was always complaining on the one hand about going through the federal process, which can be quite onerous but transparent, and it felt very fair. The foundation process had the opposite problems. You had to know somebody, you had to get in the room to be able to make your case, and then it seemed like somebody was in the back throwing darts. How was the decision being made?

What we have committed to in our program is to try to be transparent about our decision process by saying up front to people we want to see very pragmatic outcomes when it comes to persistence and retention and we are going to measure our success based on that. When things don't work that's fine, and we are going to tell people when they don't work. When we discover things that are promising and we want to double down on it, we are going to try to do that as best we can. It remains to be seen whether those commitments made in the abstract can really be followed through on. We are only just beginning and I am not expecting it to be an easy cruise on my surfboard, but I am hopeful. • **Ryan Kelsey**

Community Colleges

- Susan Singer mentioned a coordinated and coherent effort in NSF in the creation of these portfolios. Where does President Obama's emphasis on community colleges fit into the overall scheme? • **Participant**

- Community colleges are central and a very high priority. For the last four years within EHR, we have had a target of providing a minimum of $100 million a year in funding for community colleges, so it's a very specific focus and intentionality. Our Advanced Technological Education program funds $65 million dollars a year or more specifically in community colleges, though there is a small high school piece that comes along with that.

  We have a nice percentage of community colleges in this round of IUSE, and there is a substantial amount of outreach to community colleges. There is also, for example, the tribal colleges with some really terrific programs

Community Colleges and Workforce Demand

- For us, given the pragmatic rhetoric that we use, the workforce demand argument with the community college population is very attractive. We are already an active supporter of networks of community colleges and I would expect us to increase that. In some of the original exploratory grants we made in 2013 there was only a kind of dabbling in community colleges, but I think you'll see more emphasis on that in the coming year. We don't purely make decisions based on the mathematics and the numbers game, but it is an important factor combined with what we hear from trusted experts and also the values and priorities of the trust itself. But when you do the math on return on investment calculations, community colleges come out really well on those. I suspect that you'll see us doing a lot more with that, and the question is in what way. Do we use the association model that we've done with the four-year associations in the past year, or will there be other kinds of organizational structures that would make more sense? That's what we're deliberating about internally right now. You'll see us do more direct partnerships with both types of schools involved. • **Ryan Kelsey**

in HRD. Within the Tribal Colleges and Universities Program (TCUP) there is a partnership with engineering that involves working with partner schools. Some of the faculty from the four-year institution actually go in and teach in the two-year school and you build all of the supports and the cohorts to move students along.

We have an annual Community College NSF Day. This year we are looking to do it in the fall instead of the spring and we are talking about doing it on the Hill. We have a really terrific challenge for community college students to participate in that we are not quite ready to roll out yet. Can we do more? Yes. Do we need to do more? Absolutely. It is definitely a priority, and if you interact with community colleges, encourage them to see NSF as a place to come for funding. We also have some things rolling out soon related to Hispanic-serving institutions. Half of all Hispanic students in this country actually are in community colleges. If we are going to push on building the STEM workforce, we need everybody, and we particularly need to pay attention to those institutions. • Susan Singer

- Our programs, because they focus on particular kinds of challenges, tend to be selective in terms of the institutions that submit proposals, so the research universities program that we run has not had much interface to date with community colleges. We don't have a program specific to community colleges. What we are seeing more and more frequently over the past couple of cycles with our undergraduate teaching universities program, which primarily targets four-year institutions and primarily liberal arts colleges but other colleges that have a good track record of producing STEM students as well, is programming that is inclusive of conversations with whichever community colleges are the neighbor institutions. • Cynthia Bauerle

Closing Thoughts/Advice

- We are asking the same things of ourselves that we are asking of you with our internal evaluation plans. We want to build on evidence and we are really interested in generating evidence. We need to be able to show what's making a difference. We are accountable to all of you as taxpayers and we hope that you'll think about the same things as you do your own work. • Susan Singer

- I would reiterate this balance of risk and potential impact. Navigating that balance is what we're doing when we are making funding decisions. We do that best when the folks producing the ideas and generating the proposals that we see have done a very careful risk analysis, a strategic analysis of risk and impact for the projects that they're proposing. • Cynthia Bauerle

- I am just looking forward to this next year and getting to know more and more people who are doing great work. I would encour-

Community Colleges and the Persistence Question

- When we look at this persistence question, one of the questions institutions start looking at is where their students are coming from. It turns out that a significant fraction of the transfer students are coming from community colleges in a sort of linear path. And of course as we now know, there is a lot of movement among undergraduate students in terms of where they are sitting while they are getting their undergraduate education, and community colleges are very important institutions in that landscape. So we are seeing more proposals, we are seeing more activities in which the institutions that we grant are interacting with community colleges. • Cynthia Bauerle

age you, if you are interested in working with Helmsley, that you think beyond your own institution, that you think in a network sense, and that could be done in a lot of different ways: a formal network, and informal network, a regional network. Because we are so leanly staffed, we want to be able to achieve high impact numbers (with a certain amount of risk around it), but we need to do that with a limited number of absolute grants. What that means, if you look through our portfolio, is that you won't see grants to individual institutions. There may be a lead institution, but there will be a number of schools connected to that grant. So try to zoom out a little bit from your one institution. You have done some terrific things in thinking in an integrated way already, and some of you have done things that are across campuses, but even zoom out a little bit more from where you are right now. • **Ryan Kelsey**

Transforming the STEM Student Experience

Charles Kazilek

Vice Provost for Technology and Innovation, Arizona State University

Kathy Sutphin

Assistant Dean for Academic Affairs and Director of College Initiatives, CNMS, University of Maryland, Baltimore County

This discussion focused on dwindling dollars, interested students, the need to prepare students to be successful, the need to train teachers both at the college level and the high school level, the need to leverage resources (online resources in particular), and best practices among projects.

One innovation virtually every project pointed to was improvement in the awareness and integration of the various projects on the campus, something that is not always easy. Another is training of faculty and students, and particularly faculty. In terms of sustainability, even if these projects come to an end, projects have built in some capacity and long-term goals and the ability to keep these great ideas going, at least in a limited fashion.

There are also some unexpected benefits that tie back into the networks formed within the institutions and connecting the entities, and it is more than just people, it's the awareness. Group discussion included some really great stories about how entities that didn't even know each other or had to learn to work with each other now do, and there was also building relationships. There is an attitude shift and policy shift that occurred as well, shifting from weeding out students to a philosophy of actually building student success and retention.

The second part of the assignment regarding assessment was tougher, Kazilek notes. "These projects deal with people, with students, which poses some interesting challenges. Many talked about using surveys, but there is more that needs to be addressed. One discussion focused on the importance of having a common set of measurements and instruments that projects could use, something that is brought up at just about every NSF conference PIs go to. There is a desire for a common place, a database, a resource center. This might be something TERC could do, serve as a clearinghouse for this sort of thing, so projects don't reinvent the wheel, and so they could come to some common terms, common measurements.

"There are some quantitative measurements that can be acquired, for example, with the adaptive learning that we are doing, the technology. That comes under the big umbrella of big data. It would be great to get companies like ALEX or Smart Sparrow to make sure what we are collecting in our metadata will actually allow us as a group to use this to assess how well we're doing."

Addressing Three Overarching Questions

Three concurrent breakout groups each addressed one of the questions below. In this section, the facilitators for those groups offer a synthesis of group discussion.

- What are the innovations that have had a significant impact on transforming the STEM student experience (curricular or extracurricular, for majors or for non-majors)? How do we gather effective evidence?
- What are the innovations that have had a significant impact on broadening participation in STEM? What is the evidence of effectiveness?
- What are the innovative policies or processes that have created cultural change on your campus and have improved STEM teaching and learning? How can we design future programs to collect evidence of effectiveness?

Detailed documentation of each of the breakout groups may be found at:

nsf-i3.org/conference/

Successful Elements in the Student Experience

Q:

- What aspects of the student experience were enhanced the most? For example, you mentioned not weeding students out. Thinking about it from the student perspective, it would feel different if you felt secure. • **Joni Falk**

A:

- With the I^3 project I work on, and some of the others that have direct student involvement, there was a need to make the students feel like they belonged. The idea of knowing that we were rooting for their success, that we are their cheerleaders instead of gatekeepers, seemed to be a common factor, that we are actually spending time and money and resources to make them successful. • **Kathy Sutphin**

- It turned out that a lot of the groups do very similar things: peer-to-peer mentoring, the ability to get them involved in the science. It is what I refer to as a "don't just go study it, do it" type of thing. The other part is, "Don't just study it, help someone else learn it." A lot of the other groups are doing that as well, and some of them are doing some amazing jobs of it. • **Charles Kazilek**

A parting line, Kazilek says, is that it is hard to measure what we want to measure and agree on the results. "That seems a little convoluted, but I think that's the story of what we're addressing right here."

Broadening Participation

Ann Gates
Professor and Chair, University of Texas at El Paso

Ann Gates offers a brief description of each of the I^3 projects represented in the discussion about broadening participation (see inset page 63), as well as an overview of the main topics discussed.

Regarding evidence of effectiveness, most of the projects have internal and external evaluators. They are using traditional approaches, including student surveys, looking at increase in student awards, successful applications to graduate school. Many projects are doing pre and post surveys. They are also looking at increased enrollment in relevant programs, retention in the majors, degrees awarded, and so forth. Others are looking at the number of new grants that are awarded, collaborations that have resulted, and the number new resources for students. A lot of work is also being done in attitudinal changes. Some of the projects have conducted longitudinal studies on more mature initiatives.

A couple of projects are comparing their results against national data, looking at how their data on student outcomes compares to data that has been collected on a national basis in specific areas. For example, for work on undergraduate research or assuring access for people with disabilities, there are national databases that you can turn to for comparison.

Questions arose regarding evaluation. When there are students involved in several programs, how do you determine and disaggregate which programs are really impactful? Or is it the collective effort that causes a particular effect? Can we tease out what the impact is and which programs should get credit? One point that was brought up regarding long-term outcomes is that it might be interesting to have NSF offer

Kathy Sutphin and Charles Kazilek

mini-grants to enable projects to collect data after a project is over. Projects want to be able to look at impact beyond the short, two- to three-year term of their projects.

Increased communication across programs has had a huge impact. People that were not communicating before are now working together and collaborating.

A big question that came up was sustainability: What do we do after I^3? Several good ideas emerged from what projects are doing. One is collaborating and leveraging foundation funds (e.g., Gates, United Way) across projects and combining that with city funding. Everyone is putting in a little bit of money, and they are looking for ways to sustain that effort. Another program representative talked about working

Projects Represented in the Broadening Participation Discussion

- Central Florida's program is based on a knowledge-based community, and one of their innovations is to bring together art and STEM. STEM students talk to the art classes, and the art students then represent what they heard through their artwork. Students present their work in poster sessions and those who attend these poster galleries are drawn to the artistic representations of STEM projects.
- Puerto Rico Río Piedras is working on what they call maximizing integration, and their focus is on solid waste disposal. It's a very interdisciplinary topic, so it's bringing together faculty, teachers and students across this theme with a focus on the scholarship of teaching and learning.
- North Carolina State University is maximizing STEM outreach, doing some really interesting work with citizen science, the community college, and districts. They also have an MSP that is working on this. They are looking at outreach efforts and outcomes.
- The University of Florida Catalyzing Institutional Change in STEM project is focusing on leadership in its work with graduate students, connecting students from different projects and research efforts and giving those students more ownership over what they're doing.
- Kapi'olani Community College in Hawaii has a program called FIRE UP. They are a two-year college that is integrating research into their programs and have had great success in seeing students move on to four-year colleges. They're institutionalizing their TCUP grants.
- North Carolina A&T is enhancing biosciences and engineering education through curriculum integration, using a systems view of biology. They are changing curriculums in engineering, biology, mathematics and all of the sciences, providing a more systems view. It is a grassroots effort, bringing together all of the program leaders. There are common goals and common activities across campus.
- Spelman is focused on global research and education in STEM. They are increasing the number of females in STEM that have international research experiences, resulting in recruitment and retention of students in STEM.
- University of Texas at El Paso is focused on creating a cyberinfrastructure to build communities of practice and to promote profiles of faculty so that people on campus or outside campus can discover what work is being done in areas of interest, whether undergraduate research, peer mentoring, or particular research topics.

with the legislature and actually being able to get funding from the state. That has allowed them to create a beginning foundation to continue to elicit funds to sustain the work that they're doing. They were following the model of the MESA program out of California.

One person suggested that if you are doing projects that impact the workforce, you should look to your regional workforce boards for support. In particular, programs offering undergraduate research experiences that prepare students to be more productive in the workforce might be good candidates for this type of funding.

Finally, the group talked about broadening participation and what that means. Apparently in some institutions, and maybe it's pervasive, there is the question of what we mean when we talk about broadening participation. Do we need to define it? Participants felt that for NSF it is well-defined, but not everyone within individual institutions may really understand what it means. The NSF program officers talked about broadening participation and how NSF uses the term, and the accountability associated with that.

Ann Gates (left) and Bonne August

Innovative Policies and Processes

Bonne August

Provost and Vice President for Academic Affairs, New York City Institute of Technology

August notes the common themes emerging from the breakout session as she recaps her group's discussion. One is the idea of building capacity, which was a strong theme in this discussion about cultural change because the process isn't only about going from something to something else. It is about creating capacity in the institution to continue to evolve in the directions that you've set, or in new directions as you identify them.

This discussion group represented different kinds of institutions and different aspects of cultural change. The word "engagement" was often repeated. In some cases it was a question of engaging faculty in broadening participation (analogous to what the student experience discussion group talked about) and having them invest in that as a goal, or realizing that they were already invested in it and giving them a way to act on that.

Kapi'olani brought up another kind of engagement: engaging community college faculty in producing majors and sponsoring undergraduate research. In the process, you are also reengaging them in their disciplinary activity, from which they may have felt disconnected or not fully engaged.

The Rutgers project and Georgia Tech talked about engaging graduate students in different

ways. There is engaging graduate students in areas outside their specific disciplinary study that will have utility for them as they actually go into their careers. At Georgia Tech there is a focus on teaching, at Rutgers a focus on studying written communication and other things that make them more rounded professionals. It is changing the PhD model.

Johnson C. Smith, a relatively small institution, had success in focusing the institutional culture on STEM areas and creating a STEM identity for their institution that is extremely visible both inside and outside the institution.

The group looked at the processes that projects employed and those that led to the changes described. UC Berkeley talked about community organizing and made the very telling statement, August relates, that when you are thinking about change and engaging other people, you need to have faith that they will become engaged in the same things that are important to you. This is not converting the unconverted, this is helping identify a problem that might be of importance to them, sometimes directly, sometimes by tying it to something else that is important to them. For example, all the NSF applications require you to address broadening participation and broader impacts. If you can create alliances and collaborations, if they know you're there, that can be a powerful tool for engaging them in the cultural change activity that you are about. A large number of the projects represented in this discussion have been ADVANCE institutions, have been involved in other funding initiatives that have had impact, and have been engaged in undergraduate research.

There was a discussion of structures that embody the goal. There is the STEM center at Johnson C. Smith and the new center at the University System of Maryland. The representative from University of Texas at El Paso reminded the group that spaces are not necessarily physical. Cyberinfrastructure is another way to embody the goal, enabling you to create communication centers, shared resources, and partnerships.

There was a discussion in which Boise State in particular was vocal, regarding bottom-up and top-down approaches. Projects should identify ways in which administration can help, but also identify what change has to come from the faculty or from the students. Making all systems accessible for students creates a stronger possibility of student engagement in those learning communities for faculty, enabling faculty to discover things that might be of importance to them. The need for multiple points of entry into a project was also mentioned. Projects should not be constructed so that there is only one way in. Allow people discover that you're there and help them find their way into it.

There was discussion about the strategic use of resources in thinking about pieces you need to add. The group also looked briefly at policy which, August opines, is always harder than processes. Eliciting administrative support

The Need for Compelling Storytelling

- We are both the preachers and the choir. There's a problem with that, because we get together and we're great amongst ourselves, but what do we do beyond that? One theme here was the power of stories. In many ways we need to do a better job marketing. We have had great stories at this conference. We need to package those for the public, our faculty, and our students, so they may understand and appreciate what is going on and want to be involved. • **Charles Kazilek**

Added Suggestions from Other Participants

- Tell us a story about something that worked and how you know it worked, or something that didn't work, and why you would change it if you did it next time. While not comprehensive it would leave a little bit of a legacy if each project did a spotlight, collected on the I^3 website.
- If you have marketing or development people who write really great content text, consult with them. You all have PR departments, pull them in to turn what we are saying amongst ourselves into something that's consumable by the vast audience. We are academics and have a tendency to write for academics.
- There are other critical audiences. For example, think about communicating with legislators and decision makers. Instead of emphasizing what you think is important, you need to understand what is important to them and emphasize the kind of evidence that is acceptable or of interest to them.

is one policy strategy. One project reported that their provost promoted only the STEM disciplines in the strategic plan. August reports that she has had the opportunity promote STEM at City Tech and has put the creation of a STEM center into the strategic plan and keeps reminding the president that it's a priority.

Another policy move involved creating new degree pathways, which can create alignments between parts of the institution, between different institutions, between community colleges and four-year colleges. This creates pathways for students and pathways for faculty networking as well.

There was a lot of emphasis on evolving, August concludes, a lot of emphasis on building capacity, and the feeling that institutions had truly changed in ways that made a difference.

Policies, Processes and Gathering Evidence of Effectiveness

In the discussion regarding evidence of effectiveness, the easiest part was identifying obstacles. There was the traditional IRB bashing moment. Is any degree of risk possible, or do projects have to demonstrate that no possible negative thing could occur to anybody from those projects? Rutgers made a suggestion which might or might not be easy to implement depending on the institution. The idea was to create a mechanism in the grants office or office of sponsored programs that supports the kind of data you've got to put together, the evaluation plan that you need to present, so that you can get the IRB approval as part of the proposal development process. That is part of the institutional support for projects' grant obtaining activity.

There was a lot of discussion about the obstacles of gathering data in the first place. How do you get people to respond? What kinds of communication do you use? Everybody has got communication overload and survey fatigue. How do we get people to respond to those things? The group did not produce any easy answers for that.

There was also discussion about the difficulty, especially in small institutions, of disaggregating information because the numbers are too small. Sometimes you can't find out the things that you want to know about the groups that you're hoping to target for the interventions. As other groups mentioned, the idea of access to other databases, existing national databases, was brought up. This might give you access to information that has already been gathered about the same type of individuals or group of individuals and help you to disentangle the multiple variants in your process.

There is also formative data. The question arose of how to identify or elicit the resources you need, once you have gathered formative data, to make the changes indicated at a midpoint in your process.

Boise State reported on their use of logic models and give a great deal of thought in the planning of the project regarding what kind of data is needed about the outputs. What kind of data do we need about the outcomes? Where will we get it? The idea was setting a timetable, planning ahead, and building that into your process.

CLOSING THOUGHTS

This section offers closing thoughts from the conference thought leaders.

Jeanne L. Narum

Principal, Learning Spaces Collaborative; Director of the Independent Colleges Office

This conference has brought up the need for transparency in the process of institutional change, Narum notes. The more stories that are gathered and shared, the easier it is to convince the humanities not to be threatened by an institutional focus on STEM. The same is true of buildings. "We want to rebuild, we want to repurpose. We want transparent spaces so people can really understand what the doing of science is and see this as a community they can be part of," Narum states, and here is ample research on why you would want transparent spaces she adds.

There was talk about vision, and Narum encourages projects to think about building community as a vision. Project reports indicated that new kinds of communities are built because different kinds of conversations are happening. The shaping and repurposing of spaces presents a unique opportunity to bring all sorts of different people to the table— your facilities officer, your assessment officer, your PR person, and your major donors—resulting in lots of conversation.

What do we want our learners to become?

- Agents of their own learning
- Transdisciplinarians: Renaissance people for the digital age
- Code writers, code readers, code breakers
- Entrepreneurs. Analysts and creators of digital technologies
- Reflective practitioners of well-researched pedagogies in their use of space to support learning
- Creative thinkers, who recognize there may be a new solution
- Tolerant participants, who appreciate diversity of multiple cultures
- Effective communicators, with skills for multiple media and venues
- Enthusiastic and passionate about interdisciplinary science
- Aware that boundaries in science are artificial
- Well-trained experimentalists who think critically
- Aware of the powerful role they play in their own learning
- Connected with faculty, support providers, and peers during the learning process
- Digitally literate citizens who communicate about and use technology effectively

- Learning Spaces Collaboratory http://pkallsc.org/

Jeanne Narum

M.J. Bishop

Narum's first book on planning STEM learning spaces said that the vision when you enter into this should be that building community is both the vision of the process and of the space that you arrive at, a space that continues to build community. In talking about learning spaces, it is important to get the questions right from the beginning, Narum advises, and one of the first questions is who needs to be at the table. Where are the faculty trailblazers? The attention to the physical learning environment is really a chance to shape the future of your institution.

Currently we are constrained by spaces that have chairs bolted to the floor, and that is a mental image of how people learn. Daniel Goroff shared a quote earlier: "We could teach them in rows when they were going to work in rows." When we have different kinds of spaces, we have different mental images of how people learn. Narum opines that one of her most helpful suggestions in rethinking the space is to ask NSF Distinguished Teaching Scholars, "What is the mental image that someone would have of watching you in your classroom?"

Narum shares the first question from *The LSC Guide* (bottom of page 67), a question Narum and her team spent six months working on with the 17 campuses included in the guide.

We are not changing because we have one small vision, Narum concludes. "We've got really big visions, and spaces signal something, the vision of your institution."

M.J. Bishop

Director, Center for Innovation and Excellence in Learning and Teaching, University System of Maryland

Bishop reiterates that she is not a STEM person, she is a structural design and technology person who has given a lot of thought over many years to a definition of technology that is not about things, but rather about the ways in which we use the tools. Some of the tools are our facilities and our spaces, some of the tools are these devices, some of the tools are our understandings of systems and the way things work.

Unfortunately, Bishop notes, as human beings we have a tendency toward something called "functional fixedness," a term describing a psychological phenomenon that has been explored. One example of this involves an experiment done in the 1930s or '40s. There were two strings hanging in a room and the idea was that the participants were to hold onto one and try to reach for the other, which was just out of reach. There were tools all over the floor in the room to suggest things that the person might do to try and solve the problem, and one of the tools was a pair of pliers. Most people would pick up the pair of pliers and try to use that to extend their reach, but it still wasn't long enough. They didn't realize that what they needed to do was take the pliers, tie them to one of the strings, and use it to weight the string so that they make it into a pendulum and catch it.

The idea, Bishop explains, is that because there is a way we use a tool and have always used

that tool in the past, we have a really hard time seeing other ways in which we can use those tools. "That is true of our spaces," she says, "and I think it's true of our technologies as well. How do we get past that functional fixedness and help people start to think differently, to change the underlying culture within our institutions?" The conference has helped Bishop solidify some of her thinking around this. There is, for example, "this notion that we need to stop thinking in terms of the deficits, and instead begin building on our capacities for change."

Bishop had a colleague at Lehigh in the College of Education, with whom she worked on a mentoring program for early faculty coming into the college. At one point the colleague said, "We need to stop thinking in terms of untenured faculty and instead start calling them pretenured faculty." That anecdote speaks to the sorts of things that have been talked about in the last couple of days, Bishop observes. For example, there was what Shirley Malcom said about not asking, "What is your major?" which implies the student needs to be trained and fixed, but rather asking, "What is your question?" which implies they are in fact capable of something and we are here to help facilitate that process.

Similarly, we need to stop thinking about what we can or cannot do, Bishop suggests. "Rather, start thinking about the things that we need to be doing and believe that, in fact, if we just come up with the right combination of plays, we can figure out how to get it done and put together our game plan."

Nancy Shapiro

Associate Vice Chancellor for Education and Outreach, University System of Maryland

Shapiro observes that her notes from the conference include: sustainability, creative networks, creating community, building capacity, accessing potential, writing humanities into STEM grants, and logic models.

She also makes an observation regarding what happens in meetings like this. "We all are a tremendous resource for each other. We are a network. We are a little bit under-recognized in our home spaces and sometimes better recognized out of our home spaces." Shapiro encourages participants to think of this as a network of resource people to be brought in at various times to help do the things we can't do by ourselves on our campuses.

She shares a quote from her husband that seems to fit almost every situation she finds herself in, including this one: "We would have bacon and eggs if we had bacon, if we had eggs." Conference attendees are engaged in work akin to creating the bacon and keeping it to one side, and then creating the eggs, and then we put it all together on a plate. Very few of the people in the room have the resources to do all the work that they want to do, Shapiro notes, and it is necessary to actually construct and create that work.

"The I^3 grants are a way of seeing what the ingredients are that are out there. What we are going to try to do is lift the game and create

Nancy Shapiro

Jay Labov

that smorgasbord that we all have available to us, but it's not there yet. I just say, go out and make bacon and eggs."

Jay Labov

Senior Advisor for Education and Communication, National Research Council

Labov observes that the field is getting closer to the tipping point than it was five years ago due, in large part, to the kinds of work being done by those represented at this conference. Working in Washington at a place like the National Academy, it can be difficult to find out from the community what is really going on. "This meeting and others that I've been to are convincing me that a whole lot is really beginning to change. The way that we think about the problem is beginning to change."

For a long time the field has been institution-centered, using terms like "gate-keeping" roles, "weeding out," and "pipelines." Based on this conference and others, Labov believes we are now thinking much more about a student-centered emphasis. "We are now using 'gateways' rather than 'gatekeepers,' 'pathways' rather than 'pipelines,' suggesting that students have more opportunities to do things."

One issue that requires continuing focus, he cautions, is the issue of whether we are measuring what is easy versus what we value. We tend to value what is easy to measure rather than measuring what we value, and as a community, we have to come up with what we value. The tools the government and others have set out as ways to collect data on things like retention and persistence are relatively easy, even though there are challenges. But then there are the kinds of things that have been talked about at this conference. Shirley used the word "joy" in her keynote. How do you measure joy? "The word that I've been using is 'flourishing,'" Labov states. "How do we know that students are flourishing rather than just persisting? Persisting is a rather negative term. You just do it because you have to do it. In my day you did it because you didn't want to get drafted. That is very different from actually flourishing." This community needs to begin to redefine what it means to measure the kinds of things that we value, he states, and is beginning to come closer to a consensus about what we value. While there will obviously be institutional variations, collectively we are beginning to change the conversation.

Throughout this conference participants stressed community building, and the importance of relationships across institutions and between institutions within a region. Labov recounts an experience he had serving on an NSF review board for an initiative involving community building. One set of proposals were similar to what has been talked about at this conference: "We have this community, we've been building this together, we now have a good plan for what we want to do, and NSF can help by giving us the grant to empower that and allow it to continue." Then other type of proposal was: "Boy, that's a lot of money. If you give us

the money, we'll figure out a way to make it happen."

The fact that projects represented here are building community and showing this is possible before they even have the money suggests that there are going to be ways to sustain it afterwards. And sustainability is a critically important problem. There are many good opportunities that just get cast aside after the money goes away, Labov notes. We have to build in that institutional awareness and sustainability, and projects here talked about that.

It is important to share stories, not only about successes, but also about failures. Reflecting back to what the funding panel said earlier, we have to be prepared to take risk and we have to be supported when we take risk. "By sharing stories we not only avoid reinventing the wheel, but avoid reinventing the flat tire, and could save ourselves so much time and effort if we can begin to figure out what those things are that don't work," Labov advises.

"I would say that we are beginning to get very close now. For the first 10 years I did this I was banging my head against the wall talking to people because they weren't hearing what the research is saying. I'm feeling a whole lot more optimistic, and these last few days have made me feel even more optimistic."

Daniel L. Goroff

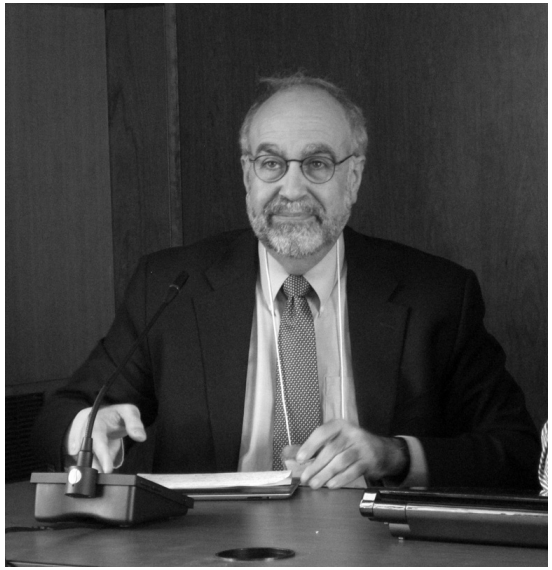
Vice President and Program Director,
Alfred P. Sloan Foundation

Goroff shares four points based on conference conversations. The first clarifies an earlier point about designing appropriate comparisons to generate evidence, and the Sloan Research Fellowships example Goroff used in his opening presentation. These are fellowships that are given to young faculty. In evaluating them it may be possible to say, "Of all of these that have been given, there are 46 of them that have gone on to win the Nobel Prize." That may or may not be a good metric, Goroff notes, but it sounds really good.

However, Goroff's question when he joined Sloan was, "Are we tracking those who didn't get a fellowship?" The question is about whether Sloan was doing a good job with the selection process. If it had turned out that among those turned down there were 50 Nobel Laureates, you may as well abandon the selection process and just flip a coin, Goroff points out. You have to think about what you're comparing things to and not just look at the examples that are at hand.

Similarly, if you are worried about retention you might just go to the people who have stuck around, because they are easily available, and ask them why they stuck around. You can find some things out that way but isn't going to help you learn about retention as much as it would if you asked the people who left. This is the whole question of context, Goroff explains.

Daniel Goroff



You cannot simply look at the obvious things after the fact. You have to plan ahead and think about how you are going to make those kinds of comparisons.

The second point is, if you do want to know about retention, think about whether that is the right framing of the problem. Yes, it is very motivational, Goroff acknowledges, it is the opposite of weeding out. "While it may do us some good to think about it that way, I also believe in evidence and data. There are data sets just coming online from the NCES the *Baccalaureate and Beyond Longitudinal Study* (https://nces.ed.gov/surveys/b&b/), allowing a careful look at what people actually take and what actually happens. It turns out, as we all know, that lots of people leave science. Lots of people leave every field that they start out in. They sort themselves around, and that's what college is for. This is preliminary data, he acknowledges, but we should think about the possibility that it is not necessarily the case that there is something special going on in science. "In fact, the evidence seems to be that just as many people come into science, to STEM fields, as leave. You don't hear about this much. It's not in the nice pictures of the leaky pipeline, but when you look carefully at the data, that might actually be the case."

If that is so, Goroff proposes, "What we should be talking about is not so much retention as just making our courses attractive, making them good experiences, and recognize that there may be on-ramps, off-ramps, and all kinds of pathways through this. It isn't a matter of just trying to hold on to a few talented kids."

Goroff urges participants to think about that framing, and think about it in terms of helping people make good choices, choices that are going to work for them, that are going to work for us, that have career paths in mind. "That, I think, is perhaps a healthier and more responsible way of doing it, and something that might just comport with some of the evidence that's coming out these days."

Goroff's third point relates to Jeanne Narum's focus on architecture, and to behavioral economics and the term "choice architecture." Just as we shape buildings and that shapes how people move around in them and what they do, the way we present decisions to people shapes their decision-making behavior. The term "nudging" comes from the book, *Nudge: Improving Decisions About Health, Wealth, and Happiness*, which can offer useful lessons in terms of how, when, where, and why we put decisions to students and what kind of information we give them so that they can make the kinds of decisions that are really going to work for them.

In conclusion Goroff advises, "Plan ahead, think about context, and keep up the good work."

ATTACHMENT: INNOVATION HIGHLIGHTS

The following highlights surfaced during conference breakout discussions and feature I³ project innovations as well as innovations from other noteworthy projects at I³ sites and elsewhere. They are loosely grouped into categories according to the nature of the breakout discussions in which they occurred.

Broadening Participation

Engaging Faculty in Diversity: A Community Organizing Approach

UC Berkeley's I³ focuses on increasing diversity in mathematical, physical and computer sciences through a series of linked opportunities for research for students, and targets a pipeline of those transitional years from the upper division at the undergraduate level through the first couple of years of graduate education up to the qualifying exams.

Efforts to engage faculty in broadening participation were based on the following premise: The same persuasive evidence that got project and university leadership committed to diversity could get many if not all of the faculty to the same place. Strategies included drawing up an initial list targeting persuadable faculty—those likely to become engaged if approached in the right way. The next step was to offer faculty information that the project leadership and dean had found persuasive. They distributed copies of Claude Steele's book, *Whistling Vivaldi*, to every member of the faculty in mathematical and physical and computer sciences, along with a letter from the dean encouraging faculty to read the book. Claude Steele was then invited to campus and faculty were encouraged to attend the talk, resulting in an overflow crowd in one of the huge engineering lecture halls. Three-quarters of the attendees were STEM faculty and grad students. Currently, faculty demand for project events and retreats exceeds available slots. Those engaged in this I³ effort are now planning a new project to build this type of capacity at other universities.

Forging New STEM Pathways at the Community College Level

The goal of the Kapi'olani Community College I³ program is to increase the number of underrepresented Native Hawaiian students in STEM fields. Efforts include a summer bridge program for high school students, for first-year students, and for second-year students as they transfer to the university. Through the I³, the college started to embed research into STEM courses, an effort that will be sustained once the grant ends. There is also a focus on transfer to 4-year institutions, which has involved the creation of four STEM discipline tracks, allowing students to identify majors at the community college level and transfer credits as they continue to a four-year institution.

Cross-Disciplinary Outreach via the Arts

The University of Central Florida I³ hires undergraduate students in the sophomore or junior level as fellows, called researchers, who work with a faculty mentor. They are required to do outreach as well as research and have a cafeteria of options to choose from, one of which is "UCF STEAM," which inserts an "A" for "Arts" into STEM. Undergraduate students who are participating in research opportunities are

African American Women in Global Undergraduate Research

The I³ project at Spelman College focuses on linking African American women from its student body to global research opportunities to provide them with undergraduate research experience. Student efforts are coordinated by a newly created campus office that works synergistically with other offices and departments, and student efforts are supporting by an intensive, structured mentoring program both before and after the international experience.

STEM Focus at the Forefront at an HBCU

Johnson C. Smith University enrolls approximately 1,400 students, 323 of which are STEM majors, with a retention rate that ranges from 86% to 92%. They have created a One-Stop Academic Success Center for Integrating Students in STEM (OASIS), centralizing all STEM-related student support services. Each one of the 323 students is assigned to STEM coaches from gateway all the way through.

A Transformational Impact: Changing Faculty Perceptions

For many years Michigan State University has had a summer research program for undergraduates, recruiting students from outside MSU to come and do research in the STEM fields in the summer. For many years that was housed in student services and the perception of the faculty was that this was a social service program, one that would help students improve. They never saw these students as potential graduate students for their programs. As part of the I^3 process, the responsibility for this summer program was transferred to the graduate schools, and faculty are now engaged in a totally different way. They are now asked to help select the students, with the bar set at admissibility to their own program. As a result, faculty now see the summer program as a recruiting tool rather than as a social commitment type of activity.

brought together with undergraduate students in an art medium class, where they do painting, sculpture, folk arts, and music. The students create some representation of the scientific work they've conducted. At the end of three weeks there is a critique, and the students have to explain the science that inspired them. The provost, who is the PI of the grant, attends this critique every semester. The project also has design students and STEM students working on posters, leading to a gallery show which hundreds of people attend. There is the science poster as well as a beautifully designed art poster that brings people into the sciences, and the posters are accompanied by an artist's statement and an engineering scientist's statement. This has proved to be an effective way of getting people to communicate with each other who might not have otherwise, and brings some science and engineering to art students, offering them a different viewpoint.

The STEM Student Experience

Undergraduate Student Leadership

The Louisiana State University I^3 project offers students a leadership experience atypical of the general STEM student experience at the undergraduate level. The I^3 ties together a number of federally funded STEM education and training programs, and two representatives from each of those programs serve on a Student Governing Council, with a sampling of students from different backgrounds and different programs coming together. The Governing Council creates seminar series and outreach activities. Its members are responsible for coming up with their own governance, electing chairs, and forming committees. They decide what committees they want and what activities they want to impact, how they're going to recruit, and how they're going to evaluate their program. Students also receive professional development to help them organize their activities.

Transforming the Freshman Experience

The Ira A. Fulton School of Engineering at Arizona State University has completely re-conceptualized the freshman engineering experience over the last three years. The required introductory engineering design course is now taught in studio format instead of a lecture-based format. There is pre-camp that takes place in the summer with groups of 200 students each, during which students form teams and get their first successful college course experience.

Peer mentors and undergraduate teaching assistants are assigned to every introductory course. The peer mentors, two-thirds of whom are women, direct the students to academic resources throughout the year and live on the same floors as the engineering students, 75% of whom live in the dorms.

Learning Partnership Model

Boise State University STEM Station fosters STEM student success and utilizes a framework of self-authorship, a framework from which students make the transition from external motivation to more internal, intrinsic motivation in their career development. Faculty participate by developing learning partnerships in the classroom and outside of the classroom to encourage that kind of student development. In these learning partnerships faculty value students as learners and collaborators and look at learning as a partnership rather than a delivery of information. The program is finding that faculty readiness to make a transition is linked to discontent and reflectiveness regarding their current practice, and is exploring ways to help faculty reach that critical juncture.

Undergraduate Research

At Kapi'olani Community college, there is an effort to infuse culture into the research for their undergraduate students. Highly effective mentoring has contributed to the success of the undergraduate research program. Success is measured in part by the amount of rewards students have received at conferences.

Learning Assistants Program

Boise State University's I^3 has been looking at how the program has influenced the development of self-authorship amongst undergraduates who are acting as learning assistants, and their learning assistants program has become institutionalized. The program has also done research on professional identity development, using that same self-authorship framework to look at how other interventions, best practices, research, undergraduate internships, service learning, and so forth, might influence student learning so that recommendations can then be made to faculty.

Working with Graduate Students

- The Rutgers IGERT Innovations project focuses on graduate student professional development and connections between graduate students and undergraduate research, training graduate students to be better mentors, better writers, and better researchers. Demand for these courses now outstrips capacity. The project has also built communities among the students. There are activities in which they get to know others who are facing similar challenges. Currently, the project is working with the administration to find ways to expand and sustain this and institutionalize the goal that every graduate student have these activities before they leave.
- The University of Florida I^3 focuses on graduate student professional development. UF had a number of NSF training grants and it had become obvious that the missing piece was development of graduate students—giving them teaching opportunities, learning how to write, and learning how to communicate. Graduate students are offered opportunities to mentor undergrads, and undergrads work on interdisciplinary projects with graduate students.
- At the Michigan State University I^3, one focus is on preparation for future faculty and connects the professional development of undergraduates with learning communities that exist for graduate students.

Establishing a Vision for Students

At the beginning of its I^3 project, the New York City College of Technology I-Cubed Incubator gathered a diverse group of people, including faculty, administrators, and program staff, to talk about how they wanted students to see the Incubator. The key idea was that of being a kind of laboratory for students from the first time that they took a STEM course.

Online Summer Prep

The University of Maryland, Baltimore County is experimenting with online prep after seeing a lot of entering STEM majors placing into college algebra (a "doomsday scenario" for a STEM major). It may be they took algebra in 7th or 8th grade and have forgotten it, or they are not taking their math placement test very seriously. To address this need, UMBC offered a free summer online course through Pearson and then allowed students to retake the placement tests to see if they could at least place

A Shift in Attitudes & Policy

At North Carolina A&T State University there was a presidential-level policy shift reflecting the fundamental paradigm shift in higher education. Instead of trying to weed students out, the goal is to help them succeed. The focus is on building student success and retention, and investing in all students.

A Shift in Student Expectations

The I^3 team at North Carolina A&T University noticed an interesting dynamic: students now come to A&T expecting a research experience. Before, you would have offer them scholarships to come. Now they come not so much for the money, which is nice, but expecting a research experience that will help their careers.

E-Portfolios

Arizona State University has been experimenting with e-portfolios. The e-portfolios can be used for institutional assessment purposes, but students can also use them as they move on.

into precalculus. The precalculus instructor serves as the facilitator and is available if students have a problem. Locals could attend an orientation session in advance, and a letter from the dean went to students' homes offering this opportunity and explaining why it was important. Students were randomly sorted and a control group had access to a Blackboard site with the algebra concepts identified and were encouraged to study the concepts on their own. The number was small, but it will be repeated with more students this summer. There were 70 students who opted into the program with 35 in each group, and about 18 students were able to change their math placement. Caution was used to assure that students didn't move into precalculus unless they were ready, with the director of advising coordinating special advising sessions with these students.

Exemplary Learning Spaces

- The Discovery Learning Research Center at Purdue was designed to be a flexible learning space where both STEM and liberal arts faculty come to be assessed, advised and nurtured. Faculty bring students to a project lab for semester-long classes. The space has a large, open area with track lighting that can be moved and change colors. Classes can be videotaped so that faculty can go back and observe student activity.

  Faculty who want to try innovative practices in education utilize the space in a variety of ways. For example, a faculty member with a large intro class of 200 to 250 students distributes them throughout the atrium and project lab. Large, flat-panel TVs, enable students to see him as he walks around with a microphone lecturing, taking that big lecture experience and transforming it into something hands-on and manageable.

- The "Classatory" at West Point, which blurs the distinction between class and lab allowing you to go back and forth seamlessly.

- The Maker Space at the University of Michigan, part of a campus-wide initiative for multilearning teaching courses with specific outcomes at the university level, which includes small grants to faculty teaching team-taught courses.

- Revamped learning spaces at the University of Maryland in Baltimore County, which has evolved into an institution that achieves more success in graduating African American undergraduates in science than any other institution in the country. Before this space redesign, they were losing their first year students in STEM fields. As one faculty member asked to design a course there noted, in the original space the students could not understand what it was to become a chemist.

Student Study Groups, Active Learning, Mentoring

The University of Maryland, Baltimore County I^3 project, iCubed@UMBC, is assessing the effectiveness of study groups, active learning discussion sections in mathematics, and mentoring (both faculty and professional staff) as interventions. To overcome student bias that study groups are for dumb students only, the project branded one of the interventions of the program by using candy and bookmarks: "Smart Students at UMBC Use Study Groups." They developed a study group toolkit and offered orientation sessions on how to form and maintain a good study group. In the iCubed@UMBC interventions, students were randomly sorted into five "teams" - study groups, faculty mentoring, staff mentoring, active learning, and the control group. In Team "faculty mentoring," faculty worked with students in their majors and showed them what it takes to be successful in a STEM discipline and offered encouragement to pursue graduate research. In Team Staff Mentoring, students received separate professional staff mentoring following a similar protocol but focused on overall success in STEM. On-going assessment is part of both mentoring interventions.

Policies and Processes

Cross-Program Communication and Collaboration

At North Carolina Agricultural and Technical State University, the I^3 was a joint project between the College of Engineering and the Department of Biology to broaden participation through undergraduate

research experiences during the academic year for biology and engineering students, using systems biology as the focal point. It also included teams of faculty from biology and engineering working together to develop a curriculum and co-teach the curriculum.

What was significant in terms of institutional impact is that because of the joint efforts between these departments, the project initiated a meeting between program managers from all of the NSF and NIH programs on campus and they began to have regular meetings together to leverage funding and collaborate on professional development and support activities for students. From there, efforts were expanded to include programs funded by the Department of Education. "If there is anything that is sustainable," Gregory Goins observes, it is that different programs are communicating, and in going through the recruitment and selection process there is some communication and less internal competition."

Broader Impacts: Coupling to the Research Mission

At Iowa State University, there is a focus on faculty development and institutional infrastructure, especially in relation to the broader impacts criterion. The attempt is to synergize across the larger NSF grants on campus to leverage some of the broader impacts work that they are doing as well as what other programs on campus are doing and make faculty aware of those broader impacts opportunities so that they build them into their own research proposals. Ultimately the goal is for faculty, or even graduate students and post-docs who are future faculty, to be able to plan better broader impacts, write better broader impacts, and evaluate their broader impacts.

Coordinating/Leveraging Efforts

- The Purdue Research Goes to School project pulls together the Noyce Scholarship Program, the Woodrow Wilson program, a federally-funded, very large Department of Energy grant, and the Discovery Learning Research Center to develop a model for taking grant challenge research and making it available and accessible for high school students.
- The University of Puerto Rico at Rio Pedras established a system of mutually beneficial relationships between the Robert Noyce Master Teacher program, IGERT, and CREST. Assistant Professor Michelle Borrero notes, "In this economy maximizing resources from one project to the other is what has made this project successful, and there has been added value to all the projects that have been integrated. By joining forces, all the participants in each of the individual projects got more. That should be a model in itself that could be applied to other institutional goals."
- At Louisiana State University the I^3 program focuses on integrating the common activities in a range of educational programs on campus, helping to avoid duplication and offer better services.
- For the Michigan State University I^3, CAFFE, the main mission was to integrate a variety of projects that "should have been linked from the beginning but were decentralized and operating without connections."

Impact on Statewide Policy

Course redesign work at the University System of Maryland focused on the courses with the largest dropout rates. The goal was to change the way the

Formalizing a Community of Practice

At Kapi'olani Community College what is now a small model of community of practice on campus has emerged, comprised of former summer institute members who meet about once a month to talk about undergraduate research and other student issues.

Bottom-Up Strategy: Teaching Portfolios and Tenure

The Center for Teaching Excellence at the University of Maryland wanted to incorporate teaching portfolios as part of the tenure assessment, but those deciding on tenure had never done a teaching portfolio, and thus had nothing on which to base their evaluation. The strategy was to have associate professors who were going up for full invite a colleague who was an assistant professor going up for tenure to a lunch underwritten by the center. They talked about teaching and helped each other develop teaching portfolios. This group of 20 or 30 pairs of faculty from across the different disciplines were then brought together to talk about what goes into teaching portfolios. The result was that the faculty who were going up to full were educated so that when they started making tenure decisions they had actually done a teaching portfolio and knew what it was they were evaluating.

Changing Perceptions and Pathways to Teaching

Georgia Institute of Technology, which had no college of education or formal pathway to become a teacher, is a primary producer of people with STEM degrees in the State of Georgia. One goal of the I^3 was to change the culture at Georgia Tech to the perception that teaching is a successful career path. Now there is acceptance at the doctoral level. All PhD students are required to do a minor. For instance, in aerospace engineering, students usually do a math minor, something that is directed towards research. There is now a higher education minor, so there are students across engineering and science who are doing their doctoral minor in higher education. They are taking courses and learning about teaching and learning, about policy, about issues in urban education, etc. At the undergraduate level, discussion is being initiated regarding an undergraduate minor in education through the liberal arts college.

courses were being taught to engage students more directly in learning. The redesign work included regularly monitoring student progress, offering assistance in different ways, using technology in different ways, and freeing up faculty members by, for example, using undergraduate learning assistants. Controlled studies were conducted to look back at what the dropout rates were before the course redesign, after the pilot, and after the full implementation. Presentation of evidence from those studies included the board of regents, which has the responsibility to spend public money well and was facing pressures regarding a shrinking budget and a shortfall in the STEM workforce. The evidence presented indicated these problems could be addressed via a number of transformational approaches. As a consequence, one of four major themes in the system's strategic plan for the next five years is "Transforming the academic model to meet the higher education and leadership needs of Maryland's 21st century students, citizens, and business." The board invested in the Center for Innovation and Excellence in Learning and Teaching and there are pockets of this work cropping up across the system, helping to facilitate academic transformation at their institutions.

A STEM-Focused Institution; New Interdisciplinary Efforts

North Carolina A&T State University is undergoing a significant transformation, building on its strengths in engineering and some of the sciences. The strategic plan is to become a STEM-focused institution over the next eight years. That strategic plan, combined with state budget cuts and efforts on the part of the I^3 project, have worked to further this goal. The budget cuts helped convince non-STEM departments that a way out for them would be to build on the reputation of the engineering programs by showing them ways they could connect. The I^3 project enhances life sciences and engineering education by focusing on systems thinking and systems biology, which uses engineering and computing principles and applies them to biological phenomena. The program can support at least 40 undergraduate students. Almost 95% of the funds are for stipends for students who can come from any discipline. The decision was that most of the funding should go to the sciences. Two-thirds of the funding is for biology and chemistry students, some are from the engineering programs, and there are some agriculture students. They are required to have an advisor and may be co-advised by an engineering and a biology professor or they may have a single advisor, but that person then has to receive training in systems biology. The metrics include one-year retention rates, which have shown significant improvement, and the number of students who go on to graduate doctorate programs. Of the 30 students, about five have now placed in the PhD programs.

Transforming Graduate Student Engagement

The University of Florida I^3 is graduate-student oriented. The idea was to engage graduate students through PIs that had research grants, and turn this into a program that the graduate students had ownership of and essentially ran. There were a number of initiatives and activities, including awards for graduate students mentoring undergraduates and students at high schools and middle schools. There were also awards for developing curriculum and for research that graduate students proposed that was interdisciplinary in nature. That included the social, behavioral and economic sciences, and the project pushed a combination of these with traditional STEM to see what kinds of activities would emerge. There was a student advisory committee that was very active, and the project generated surveys to get feedback from the students.

One of the outcomes was heavy engagement on the

part of minority students. They were in leadership roles and ran a number of programs. While the program has ended to all intents and purposes, the program for graduate students will continue. They are involved in running the research program for undergraduates and if they want to be involved in working with teachers in K-12 schools in the Gainesville area, the university will promote that. There is also a graduate student professional development piece driven by needs generated by the graduate students.

New Community College Degree Pathways, Faculty Transformation

At Kapi'olani Community College there was a strong cultural shift that occurred as a result of the I^3 project. The faculty had perceived themselves as running a math-science service department, teaching students whatever they needed in terms of basic requisites to move on. The students themselves wouldn't identify strongly with a STEM discipline until they moved on to a four-year institution. In the I^3 project, faculty began to rethink their roles and to view themselves as producing majors at the community college level. They realized they could do undergraduate research and start to write grants to the National Science Foundation and other sources. There was a shift from a service department to a department that had majors. The college developed a new degree program called ASNS, an associate of science in natural sciences, with credits transferable to a four-year institution, which began to produce majors at the sophomore and even freshman level and get students much more engaged in science.

Strategies for Interdisciplinary Synergy

At the Georgia Institute of Technology the Dean of the College of Sciences hired an Interdisciplinary Science Coordinator, whose job it is to find synergies across the sciences. The coordinator generates a weekly newsletter communicating what is being taught that week in all of the STEM intro classes and highlights ideas that present synergistic opportunities for faculty from different departments. Instead of a top-down mandate saying, "Integrate teaching in the various labs," faculty are simply informed and offered the opportunity to build on principles being discussed in another discipline.

Cyberinfrastructure, Interdisciplinary Efforts, Institutional Transformation

The I^3 grant at University of Texas El Paso is about to enter its fifth year with the CREST Cyber-ShARE Center as the anchor. The focus of the I^3 is on building a cyberinfrastructure to support collaborations across campus via a semantic-based Web portal called the Expertise Connector. The portal highlights the expertise at UTEP and provides a point from which anyone can search for and connect to the people, communities, and centers that are moving research and creative initiatives forward at UTEP. Part of this effort includes building the infrastructures to support communities of practice, disseminating information and bringing together different projects across campus. The university in coordination with the I3 investigators hold periodic engagement encounters and other activities to enable people to share their work and make connections. An annual symposium highlights the interdisciplinary work that is being done.

Because it is a priority, the provost's office is supporting interdisciplinary research with seed money. The Office of Research and Sponsored Projects has created a new position of Network Systems Manager, responsible for bringing people across campus together around particular themes.

Funding from Regional Workforce Boards

Institutionalizing Undergraduate Research

- At Hunter College, the I^3 grant was a first step in institutionalizing undergraduate research and providing institutional support for STEM undergraduate enrichment programs funded by federal agencies or through other programs. The hope is to institutionalize efforts around undergraduate research more broadly and across disciplines. Hunter held its second annual undergraduate research conference last year, a Hunter-community-based event meant to underscore culture change and celebrate undergraduate research endeavors across the disciplines.
- As part of the effort to increase the number of African American females in STEM who choose to go abroad to conduct undergraduate research, the Spelman College I^3 modified the infrastructure of the college by establishing an office to centralize the activities of the grant, the department, and the activities with students.

Local workforce boards, which are focused on creating the STEM workforce, may be willing to fund programs dealing specifically with undergraduate research experiences or providing internship or work experience for students. While workforce boards do not typically fund freshman programs, the University of Florida has found this a way to enable program continuation past the first two years.

Cross-Sector Support, Leveraging Grants, and Skin in the Game

Raleigh Promise is a cross-sector partnership targeting post-secondary success for underrepresented students that grew out of a project funded by the Bill and Melinda Gates Foundation. Since the original funding ended, the effort has shifted from affiliation with North Carolina State as the lead agent to affiliation with United Way, which will provide an infrastructure for fund raising. The collaboration includes community colleges, city government, local agencies, the university, and utilizes a "skin in the game" approach, assuring that each partner contributes and that both the city and county governments contribute funds. Because five colleges are involved in this, it was possible to leverage faculty grants to help with these projects. The partnership was innovative in working with faculty who were applying for S-STEMs, MSPs, etc., integrating their work with the underrepresented youth in each of their grants, so those grants then provided funding. Now, between faculty grants, contributions from the cross-sector partners, and with the help of the United Way, it will be possible to keep this effort going.

An Intra-University Innovation Showcase

At Arizona State University there is something called Demofest, which occurs twice a year. Thought leaders and those with a desire to share an innovation are pulled together in an event and conduct a showcase. The last one resembled speed dating. Participants were asked to move around to the different tables to see how different strategies were being implemented.

Comprehensive Integration of a Think-and-Do Learning Philosophy

North Carolina State University wants to be recognized as a campus that graduates students who think and do, who are critical and creative. Institutional policies and practices involved in making that happen include a very well funded undergraduate research program. There are I^3 teaching and learning commu-

New STEM Centers and Learning Centers

- At Johnson C. Smith University, a private HBCU, the I^3 project is called OASIS: A One-Stop Academic Student Integrated System, providing a center for all STEM-related student support services. Johnson C. Smith has a new, visually striking STEM center, which will open in 2014 and houses research as well as student services, financed by the Duke Endowment. Recently the university held a beaming ceremony, putting the last beam in place on top of the building. All of STEM students, all of the faculty, and all of the community came to sign the beam.
- The Kapi'olani Community College STEM center incorporates faculty offices, so it is both a student and faculty center and encourages students to recognize the faculty transformation from service faculty to science faculty.
- At the New York City College of Technology, where a center is in the pre-planning stages, the strategy was to ask the academic advisory council what was really needed and the response was a one-stop shop, a place where students know they can get the help that they need. Whether or not this comes to fruition, the I^3 project achievement is that something that was not talked about before is now being discussed and considered. Provost Bonne August has put the creation of a STEM center into the strategic plan and keeps reminding the president that it's a priority.
- At Georgia Institute of Technology the new undergraduate learning center, which was 10 years in the planning, serves as an intellectual home for first and second-year students. It is where all of tutoring and academic support is centered, and also houses the I^3 project. An early concern was how to make students aware of and utilize the center. Because every student at Georgia Tech takes two lab sciences, all of the introductory labs were moved into this building to assure students would access the center.

nities. Recently, a cluster faculty hiring program was created that brought faculty from different disciplinary backgrounds together, hired them as a cluster, and put them in spaces that would promote research in innovative interdisciplinary ways.

Spaces have been created on campus that also project that sense that this is a think-and-do campus. There is a Centennial Campus, which is a community of corporations and federal and state institutions, sitting right next to the College of Engineering and Textiles. The new Hunt Library opened a year ago with all of the bells and whistles, including 3-D projection spaces, moving screens, video game rooms, and all of the things you can put into a space that will allow students to just sit and think and do.

Evidence of Effectiveness

Evaluation Capacity Building: Developing a Campus-wide Community of Practice

The North Carolina State University I^3 is an evaluation capacity-building project working with about 100 STEM outreach providers all over campus, from those impacting thousands of students and hundreds of teachers to a single faculty member working with a handful of teachers or a small number of students. The project's success is measured by the degree to which they have been able to get individual outreach groups to go through a logic model process to carefully think about the outcomes they are looking for on their project, and how successful they have been in supporting that community practice as a whole across the university.

Many projects wanted to look at changes in STEM attitudes and career orientation among students as an outcome. The project created a set of instruments that ended up being wildly popular outside of the STEM outreach providers. The school systems started hearing about this, district-level STEM initiatives began happening across the state, and they have now picked up and are using these instruments. This has provided a very deep set of benchmarking data for the outreach providers to use to look at the populations of students they are working with and how they compare to students in rural eastern North Carolina districts, urban districts, females, males, etc.

An external evaluator is helping the project try to figure out how successful they have been at creating a community of practice on campus. One challenge has been the difficulty in convincing outreach providers that data-driven decision making is something they should engage in.

Catalyzing Current Resources, Examining Departmental Culture

At Arizona State University, a WIDER grant is helping to catalyze many of the current resources in data collection, at the institutional level, the course level, and the department level. For example, there is institutional data on student persistence in engineering, which includes their grades in all of their freshman STEM courses and tracking of student engagement with the undergraduate tutoring center, learning assistants, and other curricular supports, their engagement in the U2 engineering camp in undergraduate research, and engagement in other opportunities provided. A cultural anthropologist has been hired to look at departmental culture related to learner-centered practices in the physics, mathematics, chemistry, and the engineering departments, and data is being collected on that as well. There are also external analyses of math and science learning.

Randomized Controlled Trial: Key Aspects of Academic Success

The University of Maryland Baltimore County is conducting a randomized controlled trial to identify key aspects of academic success of students who have been highly successful in the Meyerhoff Program in order to disentangle effective elements and dole them out to the undergraduate population majoring in a wide number of STEM degrees to see if this can help students who don't have scholarship support be successful. The intent is to determine which of those aspects are effective and affordable so that they can be scaled up to the whole school population. For example, active learning, a component which is part of the Meyerhoff Program, is a key foundational aspect. Currently in its third cohort, the project is keeping track of every amount of information it can amass on the students so that it will be possible to slice and dice the data to determine if it is possible to figure out what happens.

Metrics

The metrics North Carolina State University is using include looking at increase in student awards at conferences, more applications to graduate school, more successful applications to admit to PhD and MS programs, new courses on campus that are team taught, papers presented, papers submitted, papers published, grants submitted, and grants awarded.

Retrospective Interviews, National Database Comparison

The University of Texas at El Paso did a longitudinal study with the Affinity Research Group (ARG) model, which included retrospective interviews regarding where the students are now and to what they attribute their success. They compared the data against national data, which was collected through the URSSA instrument, to determine whether it makes a difference for students to go through the ARG model compared to all students doing undergraduate research. A paper describing this was recently published in the July 2013 issue of the *Journal of Engineering Education*.

Survey Exhaustion and Communication Overload

The University of California Berkeley grappled with the challenge of getting students to complete emailed surveys. They found that once students open the survey, they take it and fill it out to completion. The challenge is getting them to simply open the email. Survey exhaustion and communication overload are big issues. It is extremely difficult for students to figure out what they actually ought to pay attention to, what the difference is between this and a survey on how they like the email system.